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INDUSTRIAL ENGINEERING  
EDUCATION AND TRAINING

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# **THE NATIONAL SHIPBUILDING RESEARCH PROGRAM**

## **A Shipyard Program for NPDES Compliance**

U.S. DEPARTMENT OF THE NAVY  
CARDEROCK DIVISION,  
NAVAL SURFACE WARFARE CENTER

in cooperation with  
National Steel and Shipbuilding Company  
San Diego, California

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# PENNSTATE



## Applied Research Laboratory

### Technical Memorandum

# A Shipyard Program for NPDES Compliance

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## FOREWORD

This project was performed under the oversight of The Applied Research Laboratory at The Pennsylvania State University (ARL Penn State) and National Steel and Shipbuilding Company (NASSCO). This is project number N1-95-02 sponsored by the SP-1 Environmental Effects panel of the National Shipbuilding and Research Program (NSRP). It was performed under Contract No. MU266244-D, between National Steel and Shipbuilding Company and The Pennsylvania State University.

Management of this project was conducted by the ARL Penn State Manufacturing Science Department under the guidance of Janice M. Schneider, Deputy Manager of Environmental Programs at ARL Penn State. Program development was performed by Dr. William D. Burgos, Assistant Professor of Civil and Environmental Engineering, by Dr. Gour-Tsyh (George) Yeh, Professor of Civil Engineering, and by Dr. Frederick Williams, Associate Professor of Biology, at The Pennsylvania State University, and by Mr. Jason Goodman and Mr. Brice Toth, Research Assistants at The Applied Research Laboratory.

Mr. Ron Miller, Environmental Engineer for NASSCO, served as a partner on this project, providing valuable input on shipyard practices, needs, requirements and viewpoints.

## EXECUTIVE SUMMARY

A unique software application has been developed which combines a set of three modeling programs under one user interface to allow shipyard environmental managers to perform technical environmental modeling and risk evaluation in preparation for NPDES discussions with their regulators. This suite of programs 1.) takes simple shipyard data such as slopes, areas, copper concentrations, sediment load and rainfall data, and 2.) calculates the dispersion of the copper throughout a body of water and its sediment, and then 3.) estimates the risk involved to specified aquatic organisms from the predicted pollutant levels.

The models, as packaged herein, were developed using NASSCO shipyard as the test or base shipyard. Thus, the bay modeled is the San Diego Bay and the discharge source is NASSCO's location on the bay. In addition, copper is the only pollutant considered in the model; it was selected as being one of the most toxic and difficult contaminants to control. Using the current version of the application, any facility located on San Diego Bay can easily modify the discharge location and begin to use the models. For facilities outside of San Diego Bay, additional programming will be needed to incorporate the specific tidal and bathymetry data for their own water body before the application can be used for their facility. Additional organisms can be added to the ecological risk evaluation at any time, provided that copper toxicology data is available for the organism.

A survey of regulatory agencies indicated that slightly over half of the 23 survey respondents would allow an industry to renegotiate its NPDES permit limits based upon an ecological risk assessment of the facility's discharge, although not all are currently doing so. Some respondents thought it would be 2-10 years before they are ready to do so. One regulator said that ecological risk assessment will never be used by their agency for NPDES permitting.

As the regulatory environment evolves, the 3-component modeling application herein can provide a forward-looking standardized approach for shipyards to use in complying with the Clean Water Act's NPDES discharge limitations and it can eliminate a significant portion of the cost associated with separate compliance program development by each shipyard and repair facility. If all shipyards adapt this modeling package to their own shipyard environments it would allow the shipyard industry to present a uniform approach to the regulatory agencies and to have more control over the permit limitation outcome. NPDES limits will be based on realistic site-specific ecological impacts, resulting in favorable and scientifically defensible outcomes.

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## Electronic Attachments:

### Disk 1 - Documentation Disk

APPENDIX A – REGULATORY SURVEY AND RESULTS  
APPENDIX B – SHIPYARD SURVEY AND RESULTS  
APPENDIX C – MEDLEY USER’S MANUAL  
APPENDIX D – TECPLOT SETUP INSTRUCTIONS  
APPENDIX E – GMS FEMWATER INSTRUCTIONS  
APPENDIX F – BAY/ESTUARY MODEL (B.E.S.T.) DOCUMENTATION  
APPENDIX G – SHIPYARD MODEL (PSRM-QUAL) DOCUMENTATION

### Disk 2 - Program Set-Up Disk

Set-up Medley  
Set-up Medley with Source



## 1.0 INTRODUCTION

A Shipyard Program for NPDES Compliance, N1-95-02, was funded by NSRP Panel SP-1 because shipyard pollutant discharges are regulated under the National Pollution Discharge Elimination System (NPDES), and because the burden to demonstrate that these discharges pose little risk to local ecosystems is increasingly the responsibility of the shipyard.

This project was comprised of three distinct, but interrelated, tasks resulting in data, procedures, models and guidelines that will help all shipyards to determine their site-specific sources of pollution and the effects on their own local ecosystem. Armed with this information, the shipyard environmental managers can be better prepared to meet with regulators to discuss reasonable discharge limits based on a scientifically sound, standardized approach to ecological risk assessment.

This modeling package provides a forward looking standardized approach for shipyards to use in complying with the Clean Water Act's NPDES discharge limitations. Although there will be costs involved to adapt these models for use in other shipyards and water bodies, the utilization of these models will eliminate a significant portion of the cost associated with developing separate and possibly different programs by each shipyard and repair facility. In addition, use of this package by all shipyards would present a unified approach to the regulatory agencies, allowing the shipyard industry more control over their permit limitation incomes. Limitations could be based on realistic site-specific ecological impacts, resulting in more favorable and scientifically defensible outcomes.

## **2.0 PROJECT OVERVIEW**

The goal of this project was to develop a tool to assist the shipbuilding and repair industry with NPDES permitting and compliance, standard setting and risk management. To that end, a variety of tasks were undertaken.

- A survey of EPA regulators on NPDES permitting was conducted to gather information on current permitting practices and attitudes at the various regulatory agencies.
- A survey of shipyards was conducted to determine the types of requirements that are in current NPDES permits and any modeling or prediction programs they are currently using.
- Two computer modeling programs were written or adapted from existing programs to simulate water flows and contaminant transport due to shipyard activities:
  - shipyard pollutants into the bay, and
  - dispersion of shipyard pollutants throughout the bay.
- A computer modeling program was developed to compute ecological risk to bay organisms from the site-specific shipyard pollutant concentrations.
- A user-friendly interface was developed to link the three modeling programs and to make data and file manipulation easier and more accurate for the user.

The results of this project are presented in this report. The complete set of computer modeling application is provided on a 100MB Zip disk. All documentation for the models, user's manuals, and an electronic copy of this report are provided on a second 100MB Zip disk.

## 3.0 SURVEYS

### 3.1 REGULATORY SURVEY

The Shipbuilding and Repair Industry (SIC code 3731) lacks national effluent standards, and NPDES permits for shipyards are developed differently in each state depending upon federal or state legal requirements and site-specific environmental conditions. Because the extent of variation in regulatory and NPDES permit requirements was not known, a survey was developed and conducted to determine how state regulatory agencies and EPA regional offices establish NPDES permit conditions for facilities within this industry.

Survey Objectives - The objectives of our regulatory survey were to:

1. Examine the methods used by various regulatory agencies in writing NPDES permits for the Shipbuilding and Repair Industry as compared to industry in general,
2. Determine if a shipyard can negotiate NPDES permit conditions based upon an ecological risk assessment of its discharge(s) to its receiving water; and,
3. Evaluate future regulatory trends in writing NPDES permits for the Shipbuilding and Repair Industry.

Survey Respondents - States and EPA regions bordering a major water body were initially contacted. Regulatory agencies were reached by phone and a contact person with NPDES permit writing responsibilities was identified within each agency. To maximize response rate, the contact person was notified when they would receive the survey and an appointment was set for discussion of and response to the survey over the phone.

Of the 30 states contacted, 17 were sent the survey based on their having currently active shipyards within their state. Of these 17 states, 16 responded. Most states that have shipyards within their jurisdiction are delegated authority to write NPDES permits under the CWA. Only EPA Regions 1, 2, and 6 currently write NPDES permits for shipyards and thus participated in the survey. Two states (California and Florida) have different regional offices that write permits for shipyards. These offices were contacted directly and those who responded to the survey in California were the San Diego, Los Angeles, and San Francisco regions; and the respondents in Florida were the Central and Northeast districts. Together, 23 federal and state agencies responded to the survey (Table 1).

Survey Instrument - The survey itself (Appendix A) included an introductory paragraph explaining the survey, the types of questions that were to be asked, and a short

glossary, to insure both the questioner and the respondent referred to the same definitions (Ellwood, 1997). The first set of questions dealt with how NPDES permit conditions are established for industry in general. The next set of questions focused on how NPDES permit conditions are established specifically for the Shipbuilding and Repair Industry. The last set of questions dealt with the application of an ecological risk assessment to the development of a shipyard NPDES permit.

Summary of Survey Findings - The majority of respondents indicated that most frequently a combination of chemical-specific water quality criteria, Best Professional Judgment and Best Manufacturing Practices (BMPs) are used in writing NPDES permits for shipyards. Chemical-specific Water Quality Criteria (WQC) are used to set numerical limits and are often derived from several references, including state WQC, and federal WQC referenced in the “gold book” (EPA, 1986). Over half of the respondents indicated that chemical-specific numerical limits were determined by calculations of technology-based criteria and water quality-based criteria and selecting the more stringent limit.

Respondents noted that Best Professional Judgment utilizes a combination of approaches such as reliance on historical industry-specific data, chemical analyses of the facility’s effluent, WET tests, watershed waste load allocations, hydrodynamic modeling of the receiving water, and biological monitoring of the receiving water communities.

Respondents stated that a set of BMPs would often be included in a NPDES permit for a specific shipyard activity or location. For example, several BMPs which focus on the control of abrasive blasting materials, paints and fuels, and on the segregation of gate leakage water from contaminated storm water, could be required for and associated with a graving dock’s activities and discharges.

A major purpose of this survey was to determine if a commercial or Naval shipyard (or industry in general) could use the results from an ecological risk assessment to negotiate NPDES permit conditions. Obviously, an individual company will not have the technical and financial resources of the EPA and US Navy to perform the testing required to conduct a detailed ecological risk assessment one conducted for Portsmouth Naval Shipyard (NRaD and EPA, 1994). However, if the shipyard and the regulatory agency collaborate in the early stages of the risk assessment, cost-effective decisions regarding acceptable receptor species, measurement endpoints, and monitoring strategies could be made. For example, if these two groups can agree on the most appropriate chemical stressors (possibly Cu, Zn, and PAHs for a “typical” shipyard), then subsequent chemical analyses required for NPDES compliance could focus primarily on these analytes. Also, monitoring requirements for compliance could shift from chemical “end-of-pipe” measurements to biological measurement endpoints conducted on samples collected from the receiving water.

About half of the 23 survey respondents said they would allow an industry to renegotiate its NPDES permit limits based upon an ecological risk assessment of the

facility's discharge. When respondents were asked specifically when ecological risk assessment will be used by their agency for NPDES permitting, nine said they currently do so, four said within 2-5 years, one said within 5-10 years, one said never, and the rest were unsure. Most respondents did not answer questions regarding measurement endpoints, but the few agencies that did felt that a number of biological communities should be monitored and a "weight-of-evidence" approach be followed (Pease, 1996). This lack of regulatory guidance on acceptable measurement endpoints suggests that the use of an ecological risk assessment for shipyard NPDES permitting will require a collaborative effort between the shipyard and the regulatory agency.

For more information, detailed results of the survey and a paper written and published about this survey and its findings are presented in Appendix A.

### **3.2 SHIPYARD SURVEY**

*The text that follows in this section was excerpted (and edited for consistent format) from a report written for NASSCO by Won Engineering, April 1997. The full text of this report, including tabular data and a copy of the survey itself are included in Appendix B.*

This Shipyard Survey was conducted to aid in developing the ecological risk assessment model, shipbuilding and repair facilities were surveyed for current permitting specifics and requirements.

Survey Objectives - The objectives of the Shipyard Survey were to:

1. survey current NPDES regulated discharge constituent, concentration, and limitations from a wide cross-section of shipyards in the US;
2. identify any modeling programs that are currently in use by shipyards or regulatory agencies related to NPDES regulations or ecological risk assessment;
3. assess how the gathered information can be integrated into the focused monitoring program model that would result from completion of the project N1-95-02.

Survey Respondents - Eight public and commercial shipyards from the EPA regions 1, 3, 4, 6, 9, and 10 were contacted for participating in the survey and for releasing a copy of their NPDES or equivalent state permits. Six shipyards participated in the telephone interview. The NPDES permits of the eight shipyards were used for gathering information.

Survey Instrument - The survey (Appendix B) was designed by NASSCO to collect information on regulating agency, permit type, limitations (constituents and numerical concentration levels), monitoring requirements, shipyard site specifics including

existing monitoring data, pollutant sources, pollutant pathways, etc., and the use of a model for point or non-point source discharges.

Summary of Survey Findings - All eight shipyards' operations require an NPDES or state-equivalent permit. One shipyard's discharges are made of fresh water, and seven shipyards' discharges are made to brackish to salt water. The receiving bodies of water of these shipyards are used for various purposes, including agricultural, industrial, and recreational purposes.

Most of those surveyed felt that the regulating agency used best management practices (BMP) for developing their permit. All six telephone-interviewed shipyards responded that their permits were BMP based. Other commonly used approaches mentioned in the survey included use of chemical specific water quality criteria, federal water quality standards, and state water quality standards. These findings are consistent with the results of the regulatory agency survey conducted by Penn State University as another subtask of the project.

All but one shipyard were required to monitor discharge effluent. Most common permitted shipyard discharges included storm water, dock drainage and dock dewatering water, and non-contact cooling water. Table 2 summarizes the permitted discharges and numerical discharge limits of the eight shipyards. As shown in Table 2, the discharge effluent monitoring requirements vary considerably from shipyard to shipyard. Regulated constituents with numerical limitations included metals (copper, lead, zinc, total chromium, and tributyl tin), residual chlorine, phosphorus, total suspended solids, oil and grease, chemical oxygen demand, and polynuclear aromatic hydrocarbons (PAH). Four shipyards are required to do additional environmental monitoring (e.g., receiving water monitoring, biota studies, sediment monitoring, etc.). See Table 3 for the summary of the environmental monitoring requirements.

Three of the six shipyards participated in the telephone interview responded that the use of a quantitative model has been or will be involved in development of their permits. For one west coast yard in particular, the regulating agency is using collected sediment data, water column data, and toxicity information from the past 15 years to develop the yard's proposed new permit.

All six of the six telephone interviewed shipyards carried out welding, abrasive blasting, and painting operations. All responded a presence of the potential for pollutants from these operations to reach the direct discharge, airborne, and/or surface runoff pathways. All six of the six telephone interviewed shipyards employed handwipe cleaning and vessel cleaning in their operations. Five shipyards responded a presence of the potential for the pollutants from wipe cleaning and vessel cleaning operations to reach the airborne pathway and direct discharge pathway, respectively. All shipyards had various combustion sources such as boilers, compressors, generators, cranes, furnaces, ovens, and cooling towers that would present the potential for the pollutants to reach the pollutant pathways. All six yards

responded a presence of the potential for air pollutants from the crane operation to reach the airborne pathway or oil and grease left on the roadway by the cranes to reach the surface runoff pathway.

All six telephone interviewed shipyards had annual training programs that incorporated waste management, storm water management, and best management practices. Four shipyards had additional company newsletters and “talks” with employees to discuss various environmentally related subjects.

At the time of survey, four shipyards were in the process of renegotiating their NPDES permit. It was a consensus among these shipyards that the discharge and monitoring requirements were becoming more stringent in their proposed permits. Use of a quantitative modeling by shipyards or agencies was not prevalent; however, many survey participants believed that the use of a quantitative modeling would become beneficial or would be required by the regulating agencies in the future.

For more information, detailed results of the survey and the survey itself are presented in Appendix B.

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## 4.0 MODELS

### 4.1 OVERVIEW

Three models were developed to tackle the problem of quantifying the amount of non-point source pollution being discharged into a receiving body, and how much of an effect that pollution is having on the environment. These models are **PSRM-QUAL**, **B.E.S.T.**, and **ECORISK**. Figure 1 is a schematic drawing that illustrates the relationship of these three models to each other.

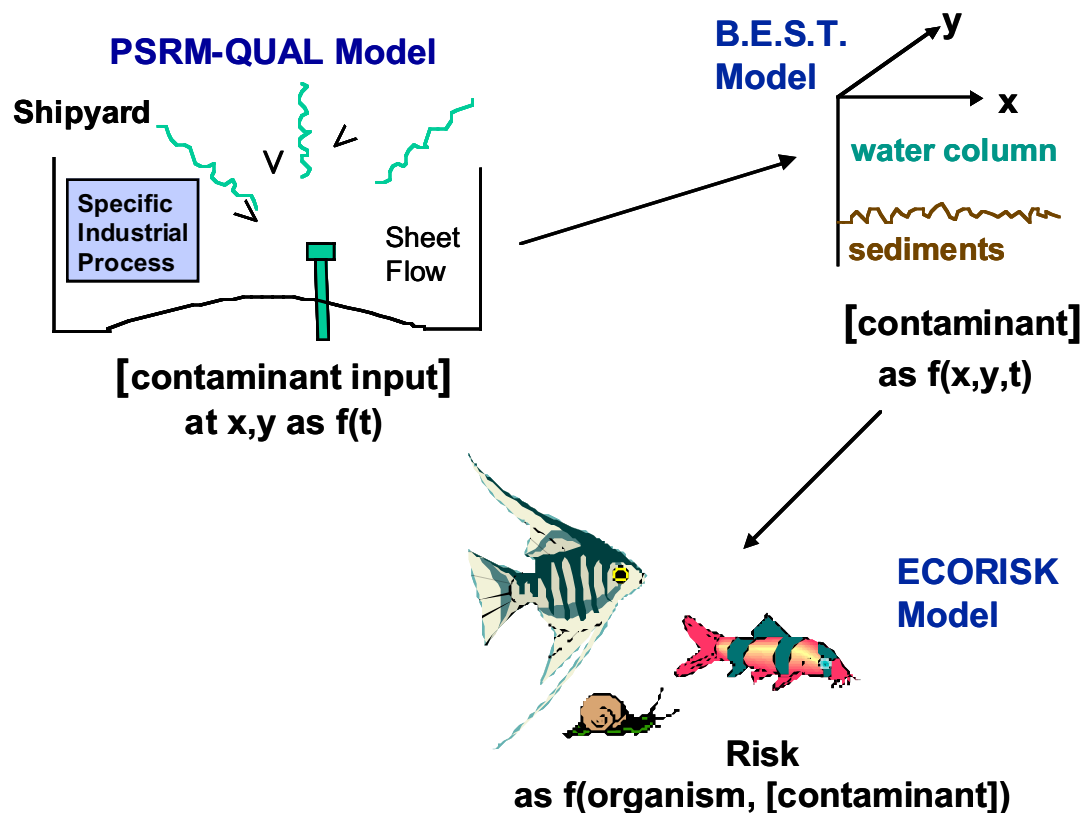


Figure 1. Schematic of the NPDES modeling logic.

The first model uses The Penn State Runoff Quality Model (**PSRM-QUAL** v95.0), developed at The Pennsylvania State University (Seibert, *et. al.*). This program models storm runoff quantities, and the amount of pollutant that is carried with this flow as a function of time. The calculated output of this model provides the input into the second model.



The second model used for this project is the Bay/Estuary Hydrodynamics and Sediment/Contaminant Transport (B.E.S.T.) model (G.T. Yeh, *et. al.*). This model simulates the hydrodynamics of the receiving water and sediments, and tracks the concentration of pollutant discharge as it is dispersed by the water currents. The output of B.E.S.T. then provides input into the third model, which considers the ecological risk posed to the receiving body by the pollution.

The third model, **ECORISK** (Williams, *et. al.*), determines the ecological risk the water column and sediment contaminant pollution concentrations pose to various receptor species. This is accomplished by comparing the output pollutant concentrations to known ecological risk criteria for a specific organism that inhabits the specific area of the receiving body.

A user interface called **MEDLEY** (Goodman) was also developed under this project. This interface allows for easy selection of the specific model to be run, organizes the files used and the data files generated by each of the three technical models, and computes data conversions and formatting necessary as the data is transferred from one model to the next.

The use of this set of modeling programs helps to give the user a complete picture of the amount and behavior of pollutant discharge and risk assessment of a specific site. Each of these programming models is described more fully in the sections below. User's Manuals with program details and specific operating instructions are included in Appendixes C, D, E, F, and G.

## 4.2 USER INTERFACE (MEDLEY)

A user interface, called **MEDLEY**, was developed to link the three technical models together and to make data and file manipulations easier for the user. A schematic of this user module logic is shown in Figure 2.

When **MEDLEY** is opened, a window is displayed which allows the user to select which of the three technical models or a data file selection process that he/she wants to run. The selected model is then opened for data entry. After the data is entered, **MEDLEY** performs the necessary calculations and formatting to properly format the output from one model so that it is accessible as input to the next model. **MEDLEY** automatically selects the proper file and folder names and places data therein so that it is available for the next program's use.

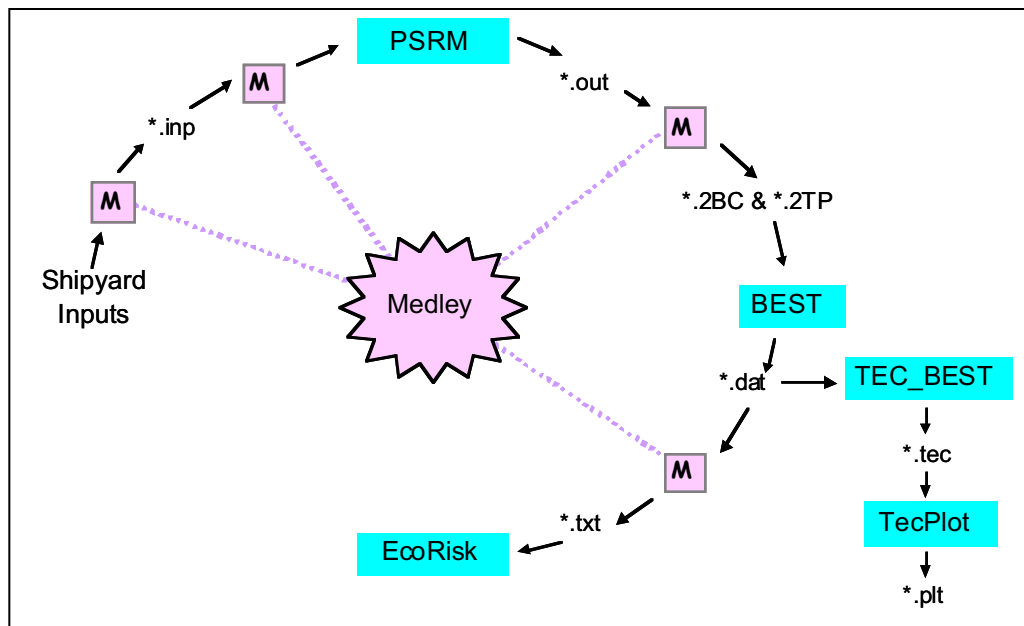


Figure 2. **MEDLEY/NPDES** program interrelationships.

#### 4.3 SHIPYARD MODEL (PSRM-QUAL)

**PSRM-QUAL** was developed in 1995 for the Pennsylvania Department of Environmental Protection to characterize contaminants in urban runoff. This program can effectively model the transport of contaminants suspended in a flowing liquid – analogous to sediments being disturbed and transported via a storm event at an industrial facility. This model was chosen and adapted for the current NSRP project for several reasons. It is accurate, relatively simple to operate, accepted by a state regulatory agency (PA), and better suited for impermeable surface flow than other storm water models that were considered.

**PSRM-QUAL** is a Microsoft Quick BASIC computer modeling program that can calculate hydrographs and pollutographs for a specific watershed associated with a specific storm event. The model works best for an impermeable watershed (e.g., paved parking lot) and has been adapted to analyze one “subarea” (i.e., individual, discrete drainage areas), each time it is run.

**PSRM-QUAL** is used to predict the amount of non-point source flow, sediment load, and sediment-associated contaminants that are transferred from a site during a storm event to the receiving water body. Through normal operations at large industrial facilities, several contaminants are deposited over the site, despite methods employed to control this contamination. These particles remain on-site until a storm

event occurs, washing the contaminants into the receiving water body via storm water systems.

There are several steps employed by **PSRM-QUAL** to simulate this event. The model employs a kinematic wave routine to predict the amount of overland water flow as a function of time. Input data is then used to predict the *total suspended sediments* (TSS) of the discharge. This TSS discharge is then multiplied by a specific contaminant concentration factor ( $F_x$ ) to determine the amount of that contaminant present in the runoff. For example, if 100 ppm of TSS is discharged during a specific storm event and 0.001 is the copper (Cu) concentration factor, then during this event, 0.1 ppm of Cu has been discharged).

**PSRM-QUAL** requires several pieces of information to accomplish this task – site information, storm characteristics, contaminant concentration factors, and most importantly, the TSS initial sediment load (ISL). Output from **PSRM-QUAL** is given in the form of a hydrograph, depicting flow versus time, and a pollutograph, depicting both TSS and the specific contaminant concentrations versus time.

To run the model, sufficient site data must be collected to adequately describe the facility. The computer modeling techniques attempt to predict natural processes; therefore, it is vital that actual site data be used wherever possible, as precise input leads to precise output. For the study case herein, much of the data was incomplete, and the input values had to be back-calculated, or assumed.

A preferred set of site input data would include the following items:

- Slope of the site
- Area of site being serviced by each specific storm water outfall
- Storm water discharge data as a function of time for each storm water outfall
- TSS data (as a function of time) taken from storm water outfalls during storm events
- Specific contaminant concentration (as a function of time) taken from storm water outfalls during storm events
- Precipitation data taken detailing the amount of precipitation as a function of time during storm events
- Fraction of site surface that is impervious
- Characteristic flow path (representative of the average flow path length for each storm water outfall)
- General site characteristics, such as how even the pavement is, storm water discharge practices (first flush separation, etc.)

After the data are collected, the next step is to correlate the storm flow data to the discharge data. Since data that details the amount of water discharged, and the concentration of TSS and the specific contaminant carried with this discharge are obtained, it is possible to calculate the initial sediment load of the site. This is accomplished by running the model, and modifying the storm intensity data as

needed until the discharge predicted by the model matches the storm water discharge data. Next, the initial sediment load is altered until the TSS predicted by the model matches the TSS output from the data. The same process is performed with the contaminant concentration. This process calibrates the model to successfully operate on a specific site. The entire model can then be run to generate the bay contaminant concentrations.

After **PRSM-QUAL** has been successfully executed, this output is then directed to the second phase of the program, the **B.E.S.T.** model.

#### **4.4 BAY MODEL (B.E.S.T.)**

Once point source pollutant concentrations entering a body of water over time during a rain event have been determined using **PSRM-QUAL**, the dispersion of these pollutants throughout the bay/estuary and into the sediment over time is predicted using the **B.E.S.T.** modeling program.

The **B.E.S.T.** model is a 2-D depth-averaged numerical model simulating water flow and reactive contaminant and sediment transport in bay/estuary systems. This model includes two computational modules: flow and transport.

The flow module computes flow using two modes, one that first computes circulation without taking into account eddy fluxes, and a second to then include eddy fluxes. The computed flow results are used to compute the migration of sediments and contaminants in the transport module.

Though many transport models have included updated numerical approaches to improve their computational performance, no existing water quality model, to our knowledge, has used a generic and mechanistic approach to simulate the reaction-migration behavior of non-conservative chemicals in bay/estuary areas. All existing models are either empirically-based or simulate systems containing specific reactions, and thus their applications are limited to specific systems. Unlike an empirically-based model whose model parameters might be system- or even environment-dependent, a generic and mechanistic model considers interactions among chemicals based on reaction mechanisms which are universal and can be applied to all systems. Based on our experience of modeling reactive contaminant transport in the subsurface, a generic, mechanistic approach was used to simulate reactive contaminant transport in bay/estuary areas, desiring to enhance reactive contaminant transport modeling in this field. In this transport module, suspended sediments and bed sediments whose distributions are determined through hydrological transport and erosion/deposition processes were taken into account. Any contaminant considered in this model is treated as a chemical species that can be either organic or inorganic. It may appear in the water column as a dissolved chemical, be adsorbed onto suspended or bed sediments to become particulate

chemicals, or exist in the interstitial water of the bed sediments also in dissolved form. All reactions among chemicals are assumed elementary kinetic, and reaction rates are described based on the collision theory where forward and backward rate constants can be measured experimentally. Figure 3 shows a schematic plot for the chemical reactions taken into account in the **B.E.S.T.** model.

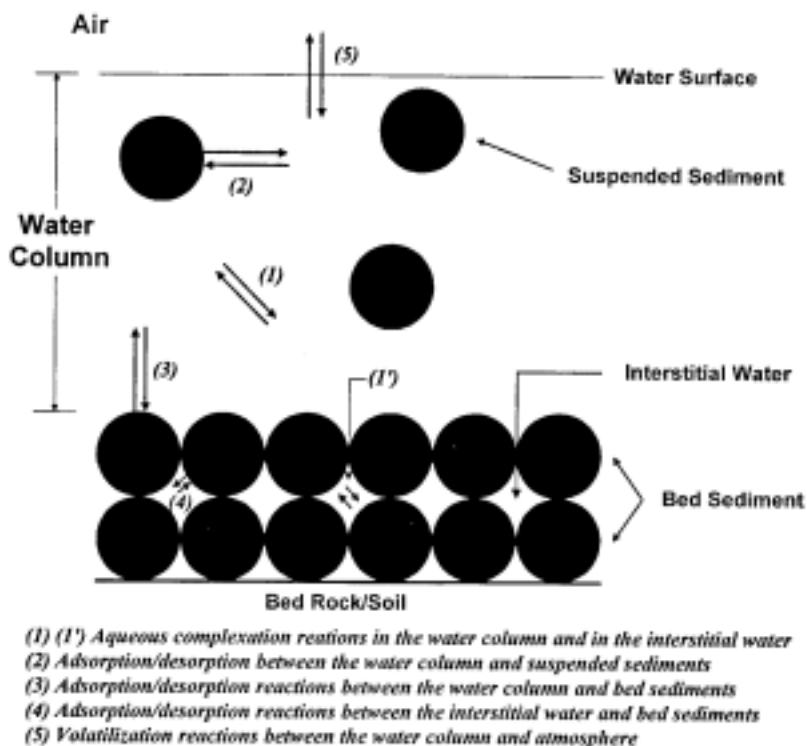


Figure 3. Schematic plot of chemical reactions taken into account in the transport module.

In developing this model, it was assumed that (1) flow fields are not influenced by sediment or contaminant distributions and that (2) sediment distributions are not affected by contaminant distributions. The first assumption lets the model compute flow and transport module sequentially, which as a result demands much less computer time than that accounting for strong coupling between flow and transport modules due to density effect. The second assumption allows the model to calculate sediment transport prior to contaminant transport.

Depending on the period of time covered in the simulation and on the speed of the computer used to do the calculations, it could take several days or longer to perform the **B.E.S.T.** calculations. **B.E.S.T.** prepares two sets of output files. One set is formatted for use in the **ECORISK** model. The second set is formatted such that it can provide a visual display of the dispersion of the pollutants within the bay over time by

opening the files using a **TecPlot** visualization software package. Figure 4 shows the dispersion of copper throughout San Diego Bay shortly after a single rain event (A), and after a 30-day simulation that included 3 rain events (B).

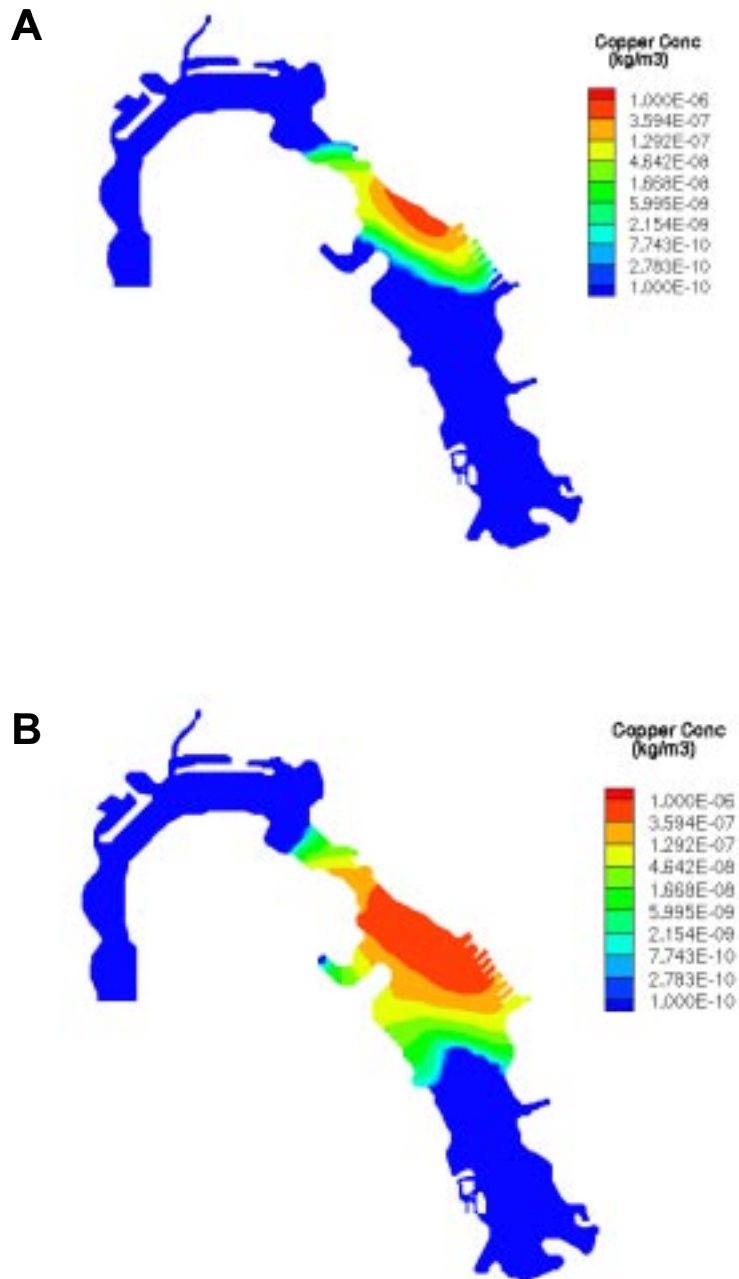


Figure 4. Dispersion simulation of copper into San Diego Bay.

#### 4.5 ENVIRONMENTAL RISK PREDICTION MODEL (ECORISK)

Once the dispersion of shipyard pollutants throughout the bay/estuary and into the sediment over time is predicted using the **B.E.S.T.** modeling program, the risk of lethal effects on species living in the bay/estuary is estimated using the **ECORISK** modeling program.

**ECORISK** calculates risk, based on the Tier 2 method presented by the Water Environment Research Foundation in *Aquatic Ecological Risk Assessment: A Multi-Tiered Approach* (Project 91-AER-1, 1996). The Tier 2 method estimates risk by comparing the mean and standard deviation of the Expected Environmental Concentration (EEC) to the mean and standard deviation of the Environmental Risk Criteria (ERC). **ECORISK** is calculated in the same way, utilizing the **B.E.S.T.**-generated copper concentrations as the Expected Environmental Concentration and the LC50 found in the literature as the Environmental Risk Criteria.

The **ECORISK** model is a C++ program with a Windows interface for entering data and selecting desired calculation parameters.

The **ECORISK** model first allows the user to establish a database of organisms that live in the bay/estuary being modeled and that are of importance to local regulators and authorities. The database includes information on the preferred habitat of the organism (water or sediment, and x,y locations within the bay), and the acute and chronic LC50 for the organism when exposed to copper.

The **ECORISK** model then uses the contaminant concentrations and dispersion data generated by the **B.E.S.T.** model, together with copper risk criteria (LC50) for any particular resident species of interest, to calculate the risk of exposure for the given species to copper concentrations above its LC50 over all or part of the bay. Risks of exposure to either acute or chronic LC50 concentrations can be calculated, and these can be based on copper concentrations that are averaged over time, space, or overall.

## 5.0 HARDWARE AND SOFTWARE REQUIREMENTS

### Hardware Requirements:

256 MB 100 MHz RAM  
600 MHz Pentium III  
20 GB Type EIDE Disk space  
512KB L2 CACHE

**MEDLEY** set-up software and associated modeling software as provided with this report.

### Software Requirements (both optional):

#### **TecPlot** Version 7.0 or later

Available from: Amtec Engineering, Inc.  
13920 SE Eastgate Way, STE. 220  
Bellevue, WA 98005 USA  
1-800-676-7568  
[www.amtech.com](http://www.amtech.com)  
[sales@amtech.com](mailto:sales@amtech.com)

#### **GMS-FEMWATER** 2.1 or later

Free for DoD contractors, See Appendix E



## 6.0 BIBLIOGRAPHY

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## **Appendices and Electronic Attachments**

Due to size limitations and format requirements, not all items are included in this file:

Appendix A - part of this file

Appendix B - part of this file

Appendix C - part of this file

Appendix D - part of this file

Appendix E - part of this file

Appendix F - separate file

Appendix F - BEST software (FORTRAN code) - separate file

Appendix G - separate file

Program - Set-up Medley - separate file

Program - Set-up Medley with Source - separate file

## **APPENDIX A - REGULATORY SURVEY AND RESULTS**

APPENDIX A from *A Shipyard Program for NPDES Compliance*, NSRP Task N1-95-02, Applied Research Laboratory, State College, PA, July 2000

## Survey of Regulatory Agencies Concerning Shipyard NPDES Permitting

The purpose of this survey is to determine how NPDES permits are established and applied to the shipbuilding and vessel repair industry. The first grouping of questions addresses how NPDES permit limits are established in a general context for industrial dischargers. The next set of questions concerns how NPDES permit limits are established for shipyards and, in general, how that industry is regulated. The last few questions deal with the concept of applying ecological risk assessment to the determination of shipyard NPDES permits. A short glossary is provided here at the beginning of the survey to insure that there is a mutual understanding of the different terms used herein.

### Glossary

**chemical-specific water quality criteria** – numerical maximum allowable water column concentration for a specific chemical constituent.

**chemical-specific sediment quality criteria** – numerical maximum allowable sediment concentration for a specific chemical constituent.

**whole effluent toxicity WET) criteria** – chemical criteria developed from acute and chronic toxicity tests to measure the toxicity of a wastewater.

**biosurvey** – collecting, processing, and analyzing a representative portion of the resident aquatic community to determine its structural and/or its functional characteristics.

**ecological risk assessment** – application of EPA’s “Framework for Ecological Risk Assessment” (USEPA, 1992; Norton et.al., 1992) to characterize ecological effects of specific chemical stressors to the receiving water by choosing specific measurement endpoints and relating them to a particular endpoint.

**stressor** – chemical constituent (e.g., copper) that causes ecological damage (stress).

**measurement endpoint** – quantifiable indicators of ecosystem health.

**assessment endpoint** – environmental conditions or processes that are valued but may not be directly quantifiable.

**tissue analyses** – tissue analyses of fishes, invertebrates, or other organisms to monitor for chemicals which may be below analytical detection limits and/or may pose a threat to human health through bioaccumulatory pathways.

**mixing zone** – an allocated impact zone where water quality criteria can be exceeded provided acutely toxic conditions are prevented.

**biological criteria (biocriteria)** – narrative expressions or numerical values of the biological characteristics of aquatic communities based on appropriate reference conditions. Biocriteria serve as an index of aquatic community health.

**biological monitoring** – monitoring/sampling of the biological population in the receiving water to determine if it has been impacted by the discharge.

### **Survey Questions**

This first set of eleven questions is about how your agency issues NPDES permits, regardless of specific industrial classification.

- 1. For process waters, which of the following approaches are used by your agency in developing NPDES permit limits? Choose as many as apply.**

chemical-specific water quality criteria \_\_\_\_\_  
chemical-specific sediment quality criteria \_\_\_\_\_  
whole effluent toxicity (WET) criteria \_\_\_\_\_  
biosurveys \_\_\_\_\_  
ecological risk assessments \_\_\_\_\_  
tissue analyses \_\_\_\_\_  
biological criteria (biocriteria) \_\_\_\_\_  
assignment of mixing zones \_\_\_\_\_  
Best Management Practices (BMPs) \_\_\_\_\_  
best professional judgment \_\_\_\_\_  
other \_\_\_\_\_

- 2. Does your agency require biological monitoring to verify compliance with NPDES permits?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

- 3. If you said “Yes” to #2, what biological communities in the receiving water do you require to be monitored?**

free swimming benthic invertebrates \_\_\_\_\_  
sessile, filter feeding benthic invertebrates (e.g., oysters) \_\_\_\_\_  
fishes \_\_\_\_\_  
plants (including algae) \_\_\_\_\_  
other \_\_\_\_\_

4. How does your agency measure the biological impact of a facilities discharge to the receiving water?

whole effluent toxicity (WET) tests \_\_\_\_\_  
tissue analyses \_\_\_\_\_  
bioconcentration factors \_\_\_\_\_  
species abundance \_\_\_\_\_  
population dynamics \_\_\_\_\_  
other \_\_\_\_\_

5. Does your agency issue separate permits for stormwater and process water?

Yes \_\_\_\_\_  
No \_\_\_\_\_

6. If you checked "Yes" to #5, which of the following approaches are used by your agency in developing stormwater NPDES permit limits? Choose as many as apply.

chemical-specific water quality criteria \_\_\_\_\_  
chemical-specific sediment quality criteria \_\_\_\_\_  
whole effluent toxicity (WET) criteria \_\_\_\_\_  
biosurveys \_\_\_\_\_  
ecological risk assessments \_\_\_\_\_  
tissue analyses \_\_\_\_\_  
biological criteria (biocriteria) \_\_\_\_\_  
assignment of mixing zones \_\_\_\_\_  
Best Management Practices (BMPs) \_\_\_\_\_  
best professional judgment \_\_\_\_\_  
other \_\_\_\_\_

7. How does your agency require industrial facilities to sample stormwater?

singular grab sample \_\_\_\_\_  
composite sample \_\_\_\_\_

8. Does your agency require collection and treatment of stormwater runoff from industrial sites?

Yes \_\_\_\_\_  
No \_\_\_\_\_

**9. How frequently is stormwater sampling required?**

after every major rain event \_\_\_\_\_  
weekly \_\_\_\_\_  
monthly \_\_\_\_\_  
twice per year \_\_\_\_\_  
annually \_\_\_\_\_  
every five years \_\_\_\_\_  
other \_\_\_\_\_

**10. Would your agency allow an industry to renegotiate their NPDES permit limits based on an ecological risk assessment?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**11. If you checked “No” to question #10, when does your agency plan on integrating ecological risk assessment into their NPDES permitting strategy?**

within the next 2 years \_\_\_\_\_  
within the next 2 to 5 years \_\_\_\_\_  
within the next 5 to 10 years \_\_\_\_\_  
within the next 20 years \_\_\_\_\_  
never \_\_\_\_\_

The next twelve questions are specific to establishing NPDES permits for shipyards.

**12. Which of the following approaches are used by your agency in developing NPDES permits for shipyards? Check all which apply.**

chemical-specific water quality criteria \_\_\_\_\_  
chemical-specific sediment quality criteria \_\_\_\_\_  
whole effluent toxicity (WET) criteria \_\_\_\_\_  
biosurveys \_\_\_\_\_  
ecological risk assessments \_\_\_\_\_  
tissue analyses \_\_\_\_\_  
biological criteria (biocriteria) \_\_\_\_\_  
assignment of mixing zones \_\_\_\_\_  
Best Management Practices (BMPs) \_\_\_\_\_  
best professional judgment \_\_\_\_\_  
pretreatment standards for POTW \_\_\_\_\_

**13. If you checked “chemical-specific water quality criteria” in question #12:**

**a) How are those criteria determined? Check all which apply.**

federal water quality standards \_\_\_\_\_  
referencing water quality criteria in the “Gold Book” or “Blue Book” \_\_\_\_\_  
state water quality standards \_\_\_\_\_  
considering ambient pollutant concentrations \_\_\_\_\_  
pretreatment standards for POTW \_\_\_\_\_  
best professional judgment \_\_\_\_\_  
calculations of technology based limits and water quality  
based limits then choosing the more stringent \_\_\_\_\_  
Other \_\_\_\_\_

**b) By what means does your agency derive permit limitations? Check all which apply.**

from a two-valve, steady-state Waste Load Allocation (WLA) \_\_\_\_\_  
from a single steady-state Waste Load Allocation (WLA) \_\_\_\_\_  
from a dynamic model output \_\_\_\_\_  
direct use of the Waste Load Allocation (WLA) as a permit limit \_\_\_\_\_  
direct application of both the acute and chronic Waste Load Allocations  
(WLA) as permit limits \_\_\_\_\_  
use of a narrative “no toxicity” limit using a “pass/fail” toxicity test \_\_\_\_\_  
use LC<sub>50</sub>>100 percent effluent at the end of the pipe to set limit \_\_\_\_\_  
other \_\_\_\_\_

**c) What are the chemical limits for metals, which your agency uses, based upon?**

Total Recoverable Metals (TRM) \_\_\_\_\_  
Dissolved Metals (DM) \_\_\_\_\_

**d) Is a computerized hydrolic model of the receiving water used by your agency in the derivation of chemical specific limits for individual discharges?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**14. If you checked “chemical-specific sediment quality criteria” in question #12:**

**a) What do those criteria address?**

Human health \_\_\_\_\_  
Indigenous biota health \_\_\_\_\_  
Ecosystem health or community structure \_\_\_\_\_



**b) Does your agency have sediment criteria for any of the following chemicals?**

copper \_\_\_\_\_  
chromium \_\_\_\_\_  
zinc \_\_\_\_\_  
lead \_\_\_\_\_

oil & grease \_\_\_\_\_  
iron oxides \_\_\_\_\_  
tributyl tin (TBT) \_\_\_\_\_  
solvents \_\_\_\_\_

**c) If sediment sampling is required in your state or locality, where do you require it to be conducted for a particular facility's discharge?**

at the outfall \_\_\_\_\_  
in the zone of initial dilution \_\_\_\_\_  
throughout the mixing zone \_\_\_\_\_  
at the edge of the mixing zone \_\_\_\_\_  
beyond the mixing zone \_\_\_\_\_  
several specified locations throughout receiving water \_\_\_\_\_  
along the property line/boundary \_\_\_\_\_  
other \_\_\_\_\_

**d) With what frequency do you require sediment sampling?**

annually \_\_\_\_\_  
every five years \_\_\_\_\_  
other \_\_\_\_\_

**15. If you did not check "chemical-specific sediment criteria" in question #12, when do you expect your agency to promulgate such criteria?**

within 1 to 2 years \_\_\_\_\_  
within 2 to 5 years \_\_\_\_\_  
within 5 to 10 years \_\_\_\_\_  
within 10 to 25 years \_\_\_\_\_  
never \_\_\_\_\_

**16. If you checked "whole effluent toxicity (WET) criteria" in question #12:**

**a) What types of organisms are used in toxicity studies for shipyard discharges?  
Check all that apply.**

invertebrates \_\_\_\_\_  
fishes \_\_\_\_\_  
plants \_\_\_\_\_

**b) Are the organisms used in the toxicity studies indigenous to the receiving water?**

Yes \_\_\_\_\_

No \_\_\_\_\_

**17. If you checked “tissue analyses” in question #12:**

**a) Does your state or locality consider bioconcentrating pollutants in their development of permit limits?**

Yes \_\_\_\_\_

No \_\_\_\_\_

**b) If “Yes,” what method does your agency use to make such a determination?**

Bioconcentration Factor (BCF) \_\_\_\_\_

Bioaccumulation Factor (BAF) \_\_\_\_\_

Biota-Sediment Accumulation Factor (BSAF) \_\_\_\_\_

other \_\_\_\_\_

**c) Does your agency consider bioavailability of pollutants in determination of permit limits?**

Yes \_\_\_\_\_

No \_\_\_\_\_

**18. If you checked “biological criteria (biocriteria)” in question #12:**

**a) What is the reference biological community:**

free swimming benthic invertebrates \_\_\_\_\_

sessile, filter feeding benthic invertebrates (e.g., oysters) \_\_\_\_\_

fishes \_\_\_\_\_

plants (including algae) \_\_\_\_\_

others \_\_\_\_\_

**19. If you checked “assignment of mixing zones” in question #12:**

**a) Where are your agency’s water quality criteria applied?**

end of pipe \_\_\_\_\_

edge of mixing zone \_\_\_\_\_

other \_\_\_\_\_

**b) In determining a mixing zone, which do you use?**

steady-state model \_\_\_\_\_  
dynamic model \_\_\_\_\_  
dye studies \_\_\_\_\_  
other \_\_\_\_\_

**c) Are there separate boundaries within the mixing zone for acute and chronic criteria?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**d) Is there a size restriction on the extent to which a mixing zone can be applied?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**e) Is there a restriction as to how high the dilution ratio can be set for a mixing zone?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**f) Can the size of a mixing zone be negotiated based upon a computerized hydrologic model of the receiving water environment?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**g) Can the dilution ratio of a mixing zone be negotiated based on a computerized hydrologic model of the receiving water environment?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**h) If you checked “Yes” to #19g, what basic type of computerized hydrologic model would you require?**

two dimensional model \_\_\_\_\_  
three dimensional model \_\_\_\_\_  
other \_\_\_\_\_

**20. If you checked “Best Management Practices (BMPs)” in question #12:**

**a) Are BMPs integrated into the NPDES permits?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**b) Are BMPs developed by your agency?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**c) Are BMPs developed by the shipyards?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**d) Are the BMPs developed through a cooperative effort between the shipyards and your agency?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**e) How many total BMPs have been developed for application to shipyards?**

\_\_\_\_\_

**f) How many BMPs are typically used in a single shipyard permit?**

\_\_\_\_\_

**21. If you checked “best professional judgment” in question #12, what does this approach involve? Check all that apply.**

whole effluent toxicity (WET) studies \_\_\_\_\_  
chemical analysis of the effluent \_\_\_\_\_  
reliance on historical data concerning the particular industry \_\_\_\_\_  
modeling of the receiving water and the impact of the discharge \_\_\_\_\_  
biological monitoring of selected communities within the receiving  
water to determine the impact of the discharge \_\_\_\_\_  
Waste Load Allocations (WLA) and permit limit derivation \_\_\_\_\_  
from two-value, steady-state outputs \_\_\_\_\_  
other \_\_\_\_\_

**22. Does your agency require biological monitoring of shipyard receiving waters to verify compliance with NPDES permits?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**23. What biological communities in a receiving water do you require to be monitored for impacts due to common shipyard pollutants? Check all that apply.**

free swimming benthic invertebrates \_\_\_\_\_  
sessile, filter feeding benthic invertebrates (e.g., oysters) \_\_\_\_\_  
fishes \_\_\_\_\_  
plants (including algae) \_\_\_\_\_  
others \_\_\_\_\_

The last four questions deal specifically with the application of an ecological risk assessment to determine a shipyard's NPDES permit.

**24. When would you allow a shipyard to conduct and use an ecological risk assessment? Check all that apply.**

in the NPDES permit application stage \_\_\_\_\_  
to review and modify a permit before the public comment stage \_\_\_\_\_  
to open a permit up for modification during its three-year operating time \_\_\_\_\_  
other \_\_\_\_\_

**25. What is/are the biological measurement endpoint(s) your agency would require to have the shipyard consider if an ecological risk assessment was conducted? Check all that apply.**

free swimming benthic invertebrates \_\_\_\_\_  
sessile, filter feeding benthic invertebrates (e.g., oysters) \_\_\_\_\_  
fishes \_\_\_\_\_  
plants (including algae) \_\_\_\_\_  
others \_\_\_\_\_

**26. What would be the assessment endpoint you would require?**

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**27. Would your agency provide peer review if a shipyard conducted an ecological risk assessment, and cooperate with the shipyard by providing feedback as to the methodology of their study?**

Yes \_\_\_\_\_  
No \_\_\_\_\_

**Thank you for taking the time to complete this survey. If you would like a summary of the results of this survey please mark the space below and provide the address to which I should send them.**

Yes, I would like the results of this survey sent to me. \_\_\_\_\_  
No I do not want a copy of the results. \_\_\_\_\_

**Address:**

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**END**

# Regulatory Methods Used in Writing NPDES Permits for the Shipbuilding and Repair Industry

**ABSTRACT** The Shipbuilding and Repair Industry lacks national effluent standards, and National Pollutant Discharge Elimination System (NPDES) permits for shipyards are developed differently in each state depending upon federal or state legal requirements and site-specific environmental conditions. Because the extent of variation in regulatory and NPDES permit requirements was not known, a survey was conducted to determine how state regulatory agencies and EPA regional offices establish NPDES numerical limits and monitoring requirements for this industry. States and EPA regions bordering major water bodies were contacted, and 23 federal and state regulatory agencies responded. The survey asked how NPDES permit conditions are established for industry in general, and specifically for the shipbuilding and repair industry. The survey also asked how an ecological risk assessment could be applied to the development of a shipyard NPDES permit, and evaluated future regulatory trends. Survey results revealed that the regulatory methods used to develop NPDES permit conditions for shipyards or industry in general do not vary greatly. However, the use of biological monitoring (e.g., biosurveys, tissue analyses, and whole effluent toxicity (WET) tests) is applied less frequently to shipyards, while the use of mixing zones for determining chemical-specific numerical limits is applied considerably more often to industry in general.

## INTRODUCTION

The shipbuilding and repair industry lacks national effluent standards, and National Pollutant Discharge Elimination System (NPDES) permits for shipyards are developed differently in each state depending upon federal or state legal requirements and site-specific environmental conditions. Because the extent of variation in regulatory and NPDES permit requirements was not known, a survey was developed and conducted to determine how state regulatory agencies and EPA regional offices establish NPDES permit conditions for facilities within this industry.

The objectives of the regulatory survey were to:

1. Examine the methods used by various regulatory agencies in writing NPDES permits for the shipbuilding and repair industry as compared to industry in general;
2. Determine if a shipyard can negotiate NPDES permit conditions based upon an ecological risk assessment of its discharge(s) to its receiving water; and,
3. Evaluate future regulatory trends in writing NPDES permits for the shipbuilding and repair industry.

## REGULATORY BACKGROUND

### Water Quality Regulations

The Federal Water Pollution Control Act of 1972 (FWPCA) made the Environmental Protection Agency (EPA) responsible for promulgating national effluent standards for each industrial category. The EPA was required to set these standards based on pollution control technologies and on the economic achievability of compliance with the standards. More stringent discharge standards could be imposed if technology-based effluent standards did not protect receiving water quality. The Water Quality Act of 1987 (WQA) strengthened the control on specific toxic pollutants by implementing toxics-oriented water quality criteria.

The FWPCA also established the NPDES program to regulate discharges from municipal and industrial facilities. Under the NPDES program a permit would be issued to a facility specifying effluent limits, actions to be taken to meet the limits, and monitoring and self reporting requirements for those limits. States were allowed to take over the administration of the NPDES program provided their standards were as stringent as the Federal standards. Once a permit has been issued with numerical limits and monitoring requirements, the "anti-backsliding" provision in the WQA makes it difficult to relax any permit condition. The anti-backsliding provision states that a permit may not be renewed, reissued, or modified to contain effluent limits which are less stringent than the comparable limits in the previous permit.

The Clean Water Act (CWA) in force today is a combination of the FWPCA and WQA (Arbuckle 1993). The objective of the CWA is to restore and maintain

the physical, chemical, and biological integrity of the Nation's waters. To fulfill this objective, the EPA recommends that state regulatory agencies integrate the Whole Effluent Toxicity (WET) test, chemical-specific water quality criteria (WQC), and bioassessment approaches into NPDES permit writing. The EPA also advises that no single approach be considered superior to another, and that all three approaches be applied equally in order to most accurately determine the impact of a discharge on its receiving water (EPA 1991).

### Storm Water Regulations

Storm water discharges from areas of industrial activity can be a significant source of pollution and must be issued a NPDES permit under the WQA (EPA 1993). Three types of permit applications are used for NPDES storm water discharges: general permits, group permits, and individual outfall permits. Most states and EPA regional offices issue a general permit for one facility to cover all individual outfalls. These general permit requirements are likely to be less stringent than requirements under individual outfall storm water permits (Dodson 1995). Group permits would allow "representative discharge monitoring" of a single outfall to be used for all similar outfalls at a particular facility to reduce monitoring costs.

### Shipbuilding and Repair Industry Regulations

The EPA published draft effluent guidelines for the shipbuilding and repair industry to provide guidance for writing NPDES permits for shipyards (EPA 1979). However, the EPA found that the imposition of national industry-wide numerical limits was impractical because of the wide variety of industrial activities and pollutant sources present at shipyards. Instead, the document described Best Management Practices (BMPs) and associated monitoring plans to be applied to shipyards on a case-by-case basis. Although BMPs are common elements of shipyard NPDES permits, numerical contaminant limits are also regularly applied.

Because no national effluent standards exist for the shipbuilding and repair industry, numerical permit limits are based upon Best Professional Judgment (BPJ) and Best Engineering Judgment (BEJ) (Arbuckle 1993). Individual regulators write a NPDES permit for a shipyard based on their own BPJ and BEJ, facility-specific industrial practices and site-specific environmental conditions. For example, a shipyard which uses dry abrasive blasting for paint removal would have BMPs to prevent the contact of blasting material with storm water. These activity-specific BMPs may also contain numerical limits for contaminants present in the paint or blasting material. The numerical limits would be based upon BPJ/BEJ that would consider WQC and characteristics of the receiving water.

### Ecological Risk Assessment

The EPA Risk Assessment Forum's "Framework for Ecological Risk Assessment" (EPA 1992) is intended to provide a logical, uniform structure for conducting risk assessments. The framework (also known as EcoRisk) is intended to be general with respect to the nature of the stressors and the ecological systems involved. The framework consists of three major components: Problem formulation, analysis, and risk characterization. Problem formulation identifies potential stressors, ecological effects, and ecosystems at risk to initially define the nature and extent of the problem. A stressor is defined as any physical, chemical, or biological entity that can induce adverse ecological effects on individuals, populations, communities, and/or entire ecosystems (i.e., receptors) (Norton et al. 1992). Analysis evaluates the significance of exposure to ecological effects and ultimately leads to the development of correlations between stressor exposure and receptor response. Risk characterization involves a synthesis of the stressor-exposure/receptor-response information to determine the likelihood of occurrence of adverse ecological effects.

Ecological risk assessment is often associated with the remediation of hazardous waste sites and is applied under the Resource Conservation and Recovery Act, the Comprehensive Environmental Response, Compensation and Liability Act (i.e., Superfund), and the Hazardous and Solid Waste Amendments of 1984 to determine acceptable cleanup criteria. More important, the EPA also uses a form of ecological risk assessment to establish chemical-specific water quality criteria. For a single contaminant, acute and chronic toxicity data has been collected or compiled by the EPA for a number (ca. 15 to 50) of highly sensitive aquatic organisms. The range of species tested is selected to represent "generic" aquatic ecosystems in the United States. WQC for each contaminant are determined by plotting a regression for the four lowest toxic concentrations and estimating the lethal concentration for 50% of test species ( $LC_{50}$ ) corresponding to the fifth percentile (WERF 1996). WQC, therefore, are risk-based and community-based because they are designed to protect at least 95% of the species tested.

### SURVEY INSTRUMENT AND METHODS

#### Survey Respondents

A survey was conducted to determine how state regulatory agencies and EPA regional offices determine NPDES numerical limits and monitoring requirements for shipbuilding and repair facilities. States and EPA regions bordering a major body of water were initially contacted. Regulatory agencies were reached by phone and a contact person with NPDES permit writing responsibilities was identified within each agency. To maximize response rate, the contact person was notified when they would receive the sur-



vey and an appointment was set for discussion of and response to the survey over the phone.

Of the 30 states contacted, 17 were sent the survey based on their having currently active shipyards within their state. Of these 17 states, 16 responded. Most states which have shipyards within their jurisdiction are delegated authority to write NPDES permits under the CWA. Only EPA Regions 1, 2, and 6 currently write NPDES permits for shipyards and thus participated in the survey. Two states (California and Florida) have different regional offices which write permits for shipyards. These offices were contacted directly and those which responded to the survey in California were the San Diego, Los Angeles, and San Francisco regions; the respondents in Florida were the Central and Northeast districts. Altogether, 23 federal and state agencies responded to the survey (Table 1).

### Survey Instrument

The survey included an introductory paragraph explaining the survey, the types of questions that were to be asked, and a short glossary, to insure both the questioner and the respondent referred to the same definitions (Ellwood 1997). The first set of questions dealt with how NPDES permit conditions are established for industry in general. The next set of questions focused on how NPDES permit conditions are established specifically for the shipbuilding and repair industry. The last set of questions dealt with the application of an ecological risk assessment to the development of a shipyard NPDES permit.

Questions were based on information from preliminary phone conversations with personnel at regulatory agencies and in the shipbuilding industry, and on the Technical Sup-

port Document for Water Quality-based Toxics Control (EPA 1991). The survey was pretested by a state regulator familiar with writing NPDES permits for shipyards. The first shipyard-specific question (Question #12, shown below) was designed to determine the most common regulatory methods used to set numerical limits and monitoring requirements for shipyard NPDES permits. Follow-up questions asked for more detailed information regarding each regulatory method checked.

Which of the following approaches are used by your agency in developing NPDES permits for shipyards? Check all which apply.

- |  |  |
|--|--|
| <input type="checkbox"/> chemical-specific water quality criteria    | <input type="checkbox"/> biological criteria (biocriteria) |
| <input type="checkbox"/> chemical-specific sediment quality criteria | <input type="checkbox"/> assignment of mixing zones        |
| <input type="checkbox"/> whole effluent toxicity (WET) criteria      | <input type="checkbox"/> Best Management Practices         |
| <input type="checkbox"/> ecological risk assessments                 | <input type="checkbox"/> Best Professional Judgment        |
| <input type="checkbox"/> tissue analyses                             | <input type="checkbox"/> biosurveys                        |
| <input type="checkbox"/> pretreatment standards for POTW             |  |

## RESULTS AND DISCUSSION

### Shipbuilding and Repair Industry

The majority of respondents to Question #12 answered that a combination of chemical-specific water quality criteria (21 of 23 respondents), BPJ (22 of 23) and BMPs (21 of 23) are used most frequently in writing NPDES permits for shipyards (Table 1). Chemical-specific WQC were used to set numerical limits and were often derived from several references. For example, 20 of the 21 re-

TABLE 1

Regulatory methods used to write NPDES permits for the Shipbuilding and Repair Industry

Permitting Approach	Regulatory Agency																							
	AL	CA-SD	CA-LA	CA-SF	CT	FL-NE	FL-Cent	GA	HA	IL	LA	MD	ME	MS	OR	PA	SC	TX	VA	WA	EPA-1	EPA-2	EPA-6	
best management practices (BMPs)																								
best professional judgement (BPJ)																								
chemical-specific water quality criteria																								
chemical-specific sediment quality criteria																								
POTW pretreatment standards																								
whole effluent toxicity (WET) criteria																								
biological criteria																								
tissue analyses																								
biosurveys																								
mixing zones																								
ecological risk assessment																								

spondents using WQC indicated that chemical-specific numerical limits were derived from state WQC, while eight used federal WQC referenced in the "gold book" (EPA 1986). Fifteen of those respondents using WQC indicated that chemical-specific numerical limits were determined by calculating technology-based criteria and water quality-based criteria and selecting the more stringent limit.

Respondents noted that Best Professional Judgement utilizes a combination of approaches, such as reliance on historical industry-specific data, chemical analyses of the facility's effluent, WET tests, watershed waste load allocations, hydrodynamic modeling of the receiving water, and biological monitoring of the receiving water communities.

Respondents stated that a set of BMPs would often be included in a NPDES permit for a specific shipyard activity or location. For example, several BMPs which focus on the control of abrasive blasting materials, paints and fuels, and on the segregation of gate leakage water from contaminated storm water, could be required for and associated with a graving dock's activities and discharges.

A number of respondents also mentioned that the EPA has proposed national effluent limit guidelines and standards for the Metal Products and Machinery Phase I Point Source Category (EPA 1995). The Shipbuilding and Repair Industry Point Source Category is included within Phase II of this initiative. Initial data collection for Phase II began in January 1995. Further detailed characterization studies of facilities that represent the shipbuilding and repair industry are tentatively planned for 1997, and proposed effluent limits could be expected within five years (Campbell 1996).

## Industry in General

Question #1 of the survey was identical to Question #12 except it was applied to industry in general. Most regulatory methods used in writing NPDES permits for industry in general are also applied to shipyards (Table 2); however, a few differences were found for the shipbuilding and repair industry. The use of biocriteria, biosurveys, tissue analyses, and WET tests are all applied less frequently to shipyards than to industry in general. The use of mixing zones for determining chemical-specific numerical limits was also applied less frequently to shipyards (10 of 23) than to industry in general (20 of 23).

## Biological Monitoring Requirements

Biological monitoring requirements are used more frequently for industry in general than for shipyards because many other industries have higher priority pollutants present in their discharges than shipyards. For example, due to the bioaccumulative potential of dioxin, Florida uses tissue analyses as NPDES permit conditions for the pulp and paper industry's wastewaters (Noble 1996). The contaminants of potential concern associated with shipyards

are primarily heavy metals (e.g., Cu, Pb, Zn), and organics (e.g., polycyclic aromatic hydrocarbons (PAHs)) to a lesser degree. WET tests may also be applied less frequently to shipyards (18 of 23) than to industry in general (22 of 23) because these tests are conducted under freshwater conditions, while many shipyards discharge to marine environments. When WET tests are applied to shipyards, fishes (e.g., fathead minnows), free swimming invertebrates (e.g., amphipods), and sessile invertebrates (e.g., mussels) are the most common receptor species (Birosik 1997, Bron 1996, Fitzpatrick 1996, Hamil 1996, Huang 1997, Martin 1996, Pease 1996, Thomas 1996, Vu 1996). In all states surveyed, biological monitoring of the receiving water is not required of the industry but is performed by the regulatory agency to confirm that adverse effects from pollution are not occurring.

## Application of Mixing Zones

A mixing zone defines a perimeter in the receiving water around a point discharge in which acute and/or chronic WQC may be exceeded. The EPA's assumption for allowing mixing zones was that "a small area of concentrations in excess of acute and chronic criteria, but below acutely toxic releases, can exist without causing adverse effects to the overall water body" (EPA 1991). Basically, the WQC are applied at the edge of the mixing zone instead of at the end of the pipe and provide the discharger with an additional dilution factor. The EPA's formulas for calculating mixing zones apply only to rivers (EPA 1991), not to harbors or estuaries, which probably explains why mixing zones are used less frequently with shipyards. Seven of the 10 respondents using mixing zones in their shipyard permits stated that the mixing zones are determined using a steady-state hydrodynamic model in combination with field-scale dye studies for model validation.

## Sediment Monitoring Requirements

Chemical-specific sediment quality criteria (SQC) are applied by South Carolina and Washington to all industries, including shipyards, while Hawaii only applies SQC to certain priority industries (Fitzpatrick 1996, Shelley 1997, Wong 1996). The San Diego Regional Water Resources Control Board requires sediment monitoring in their NPDES permits for shipyards but they do not apply SQC. Instead, the sediment monitoring data is used to determine what areas adjacent to a shipyard are contaminated and if there is any trend in pollutant accumulation (Pease 1996). If a depositional area around an outfall is seen to be heavily polluted, corrective action would be required to prevent any further sediment contamination. This corrective action could vary from the implementation of additional BMPs or to site remediation (e.g., dredging). The NPDES permit requirement for industries to monitor sediments allows regulatory agencies to collect data for the future promulgation of SQC. Our questions asked specif-

TABLE 2

Regulatory methods used to write NPDES permits for industry in general

Permitting Approach	Regulatory Agency																							
	AL	CA-SD	CA-LA	CA-SF	CT	FL-NE	FL-Cent	GA	HA	IL	LA	MD	ME	MS	OR	PA	SC	TX	VA	WA	EPA-1	EPA-2	EPA-6	
best management practices (BMPs)																								
best professional judgement (BPJ)																								
chemical-specific water quality criteria																								
chemical-specific sediment quality criteria																								
whole effluent toxicity (WET) criteria																								
biological criteria																								
tissue analyses																								
biosurveys																								
mixing zones																								
ecological risk assessment																								
other																								

ically about the application of SQC and did not address the more basic issue of sediment monitoring. Therefore, the number of state agencies which require sediment monitoring, but do not apply SQC, may have been under reported.

Additional questions were asked about the development of SQC and their future use in NPDES permits. The EPA has focused on establishing SQC for organic contaminants using equilibrium partitioning (EqP) (DiToro et al. 1991). The EqP approach presumes that the partitioning of the contaminant between sediment organic carbon and pore water is at equilibrium, and that the pore water concentration is bioavailable. A similar approach has been considered for inorganic contaminants, where the amount of acid volatile sulfide (AVS) is presumed to control the bioavailability of sediment-associated metals (DiToro et al. 1992). While no national SQC currently exist, Washington has developed a sediment quality program, which includes the establishment of sediment impact zones, sediment monitoring requirements, chemical-specific SQC, and sediment clean up criteria (WAC 173-204). When respondents were asked when their agency was going to develop and use SQC, three said they currently are, four said within 2-5 years, one said within 5-10 years, one said within 10-25 years, two said never, and the rest were unsure.

### Ecological Risk Assessment Requirements

An ecological risk assessment was conducted by the Naval Command, Control and Ocean Surveillance Center,

RDT&E Division (NRaD) and the EPA to measure the ecological effects of contaminants released from Portsmouth Naval Shipyard (Kittery, ME) on the adjacent Great Bay Estuary (NRaD and EPA 1994). This study was performed to determine where contaminants would accumulate, measure exposure levels, and evaluate whether contaminants were adversely affecting the ecology of the estuary. A network of stations was established to measure chemical-specific water column and sediment concentrations and assess impacts on marine plants, invertebrates, and fish. The pelagic (flounder), epibenthic (lobster), invertebrate (mussels, amphipods), and eelgrass communities were identified as ecosystems potentially at risk. The ideal assessment endpoint would be to protect all these communities from adverse ecological effects from the shipyard's activities. However, quantifiable measurement endpoints are required to complete a risk assessment.

Measurement endpoints can be developed a number of ways and to varying degrees of complexity. For example, water-column toxicity could be measured with a sea urchin fertilization assay or by fish abundance, condition and tissue analyses. Sediment toxicity could be measured with an amphipod acute mortality test or by an evaluation of infaunal benthic community structure. The EPA and NRaD conducted an intensive, demonstrative study, and therefore, evaluated a range of these endpoints. The results of their assessment revealed that the contaminants of potential concern are heavy metals (Cr, Hg, Ni, Pb, Zn) and organics [polychlorinated biphenyls (PCBs), PAHs], and that indicators of ecological stress are limited to sediment depositional areas.

A major purpose of our project was to determine if a commercial or Naval shipyard (or industry in general) could use the results from an ecological risk assessment to negotiate NPDES permit conditions. Obviously, an individual company will not have the technical and financial resources of the EPA and U.S. Navy to conduct an ecological risk assessment as detailed as the one for Portsmouth Naval Shipyard. However, if the shipyard and the regulatory agency collaborate in the early stages of the risk assessment, cost-effective decisions regarding acceptable receptor species, measurement endpoints, and monitoring strategies could be made. For example, if these two groups can agree on the most appropriate chemical stressors (possibly Cu, Zn, and PAHs for a "typical" shipyard), then subsequent chemical analyses required for NPDES compliance could focus primarily on these analytes. Also, monitoring requirements for compliance could shift from chemical "end-of-pipe" measurements to biological measurement endpoints conducted on samples collected from the receiving water.

Eleven of the 23 respondents said they would allow an industry to renegotiate its NPDES permit limits based upon an ecological risk assessment of the facility's discharge. When respondents were asked specifically, when ecological risk assessment will be used by their agency for NPDES permitting, nine said currently, four said within 2-5 years, one said within 5-10 years, one said never, and the rest were unsure. Most respondents did not answer questions regarding measurement endpoints, but the few agencies that did felt that a number of biological communities should be monitored and a "weight-of-evidence" approach be followed (Pease 1996). This lack of regulatory guidance on acceptable measurement endpoints suggests that the use of an ecological risk assessment for shipyard NPDES permitting will require a collaborative effort between the shipyard and the regulatory agency.

## CONCLUSIONS

A survey was conducted to determine how state regulatory agencies and EPA regional offices determine NPDES permit conditions for the shipbuilding and repair industry. Results revealed that the regulatory methods used to develop NPDES numerical limits and monitoring requirements for shipyards or industry in general do not vary greatly. However, biological monitoring requirements and the application of mixing zones are applied less frequently to shipyards compared to industry in general. In addition, because the shipbuilding and repair industry lacks national effluent standards, and the range of activities and pollutants vary greatly among shipyards, regulators must rely more heavily on their own Best Professional Judgment for writing NPDES permits for this industry. Eleven of the 23 respondents would allow an industry to negotiate its permit limits based upon an ecological risk assessment, although

few agencies could describe which receptor species would have to be monitored for NPDES compliance. ♦

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## GLOSSARY

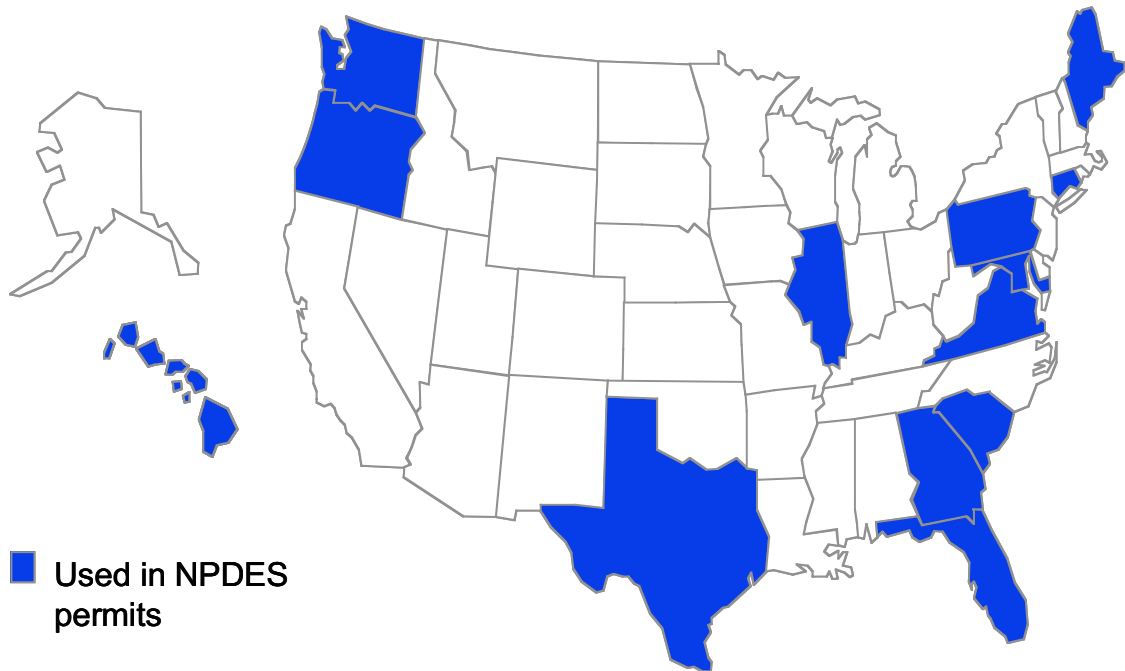
AVS	— acid volatile sulfide
BEJ	— best engineering judgement
BMP	— best management practice
BPJ	— best professional judgement
CWA	— Clean Water Act
EPA	— Environmental Protection Agency
EqP	— Equilibrium Partitioning
FWPCA	— Federal Water Pollution Control Act of 1972
LC <sub>50</sub>	— Lethal Concentration for 50% of test species
NPDES	— National Pollutant Discharge Elimination System
NRaD	— Naval Command, Control and Ocean Surveillance Center, RDT&E Division
PAHs	— Polycyclic Aromatic Hydrocarbons
PCBs	— Polychlorinated Biphenyls
SQC	— Sediment Quality Criteria
WET	— Whole Effluent Toxicity
WQA	— Water Quality Act of 1987
WQC	— Water Quality Criteria

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**Alexander Ellwood** completed a BS in Environmental Resources Management and a MEng in Environmental Engineering at Penn State.

## Chemical-specific Water Quality Criteria

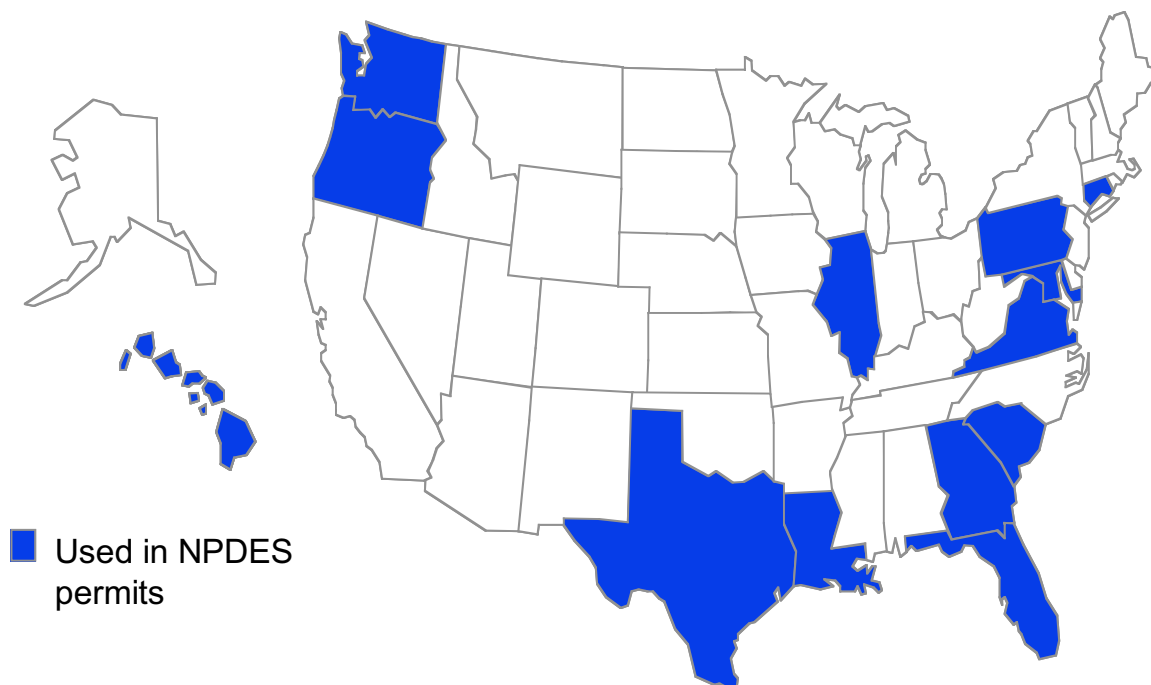
*Numerical maximum allowable water column concentration for a specific chemical constituent*





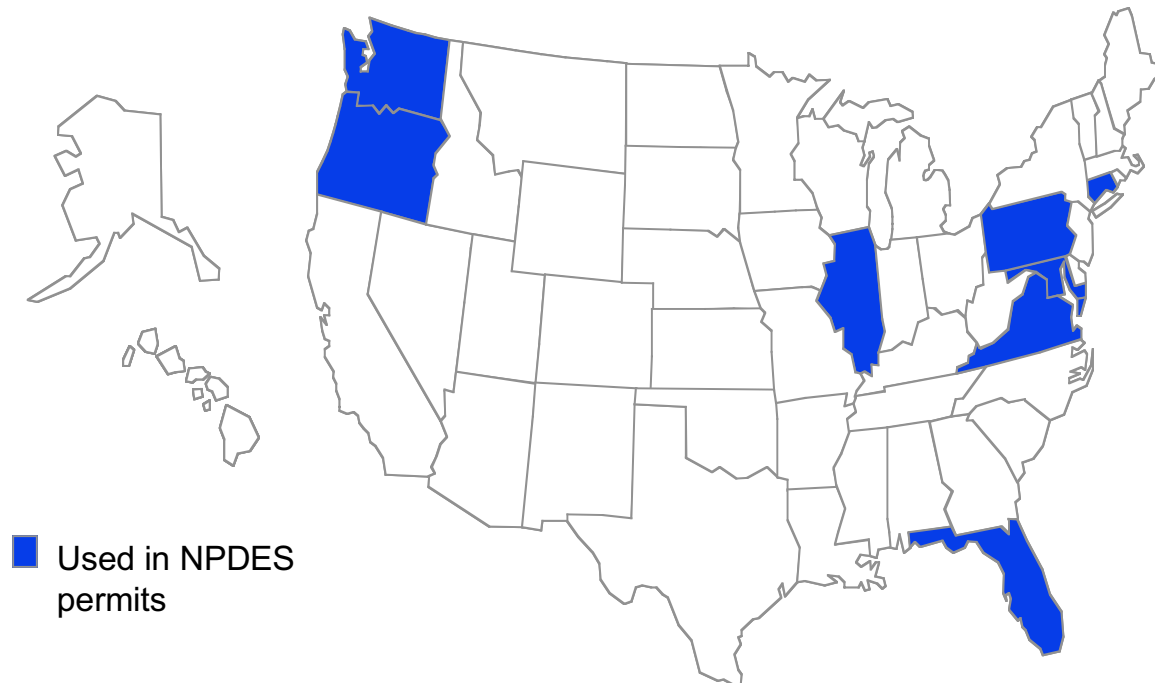
## Whole Effluent Toxicity (WET) Criteria

*Chemical criteria developed from acute and chronic toxicity tests to measure the toxicity of a wastewater*



## Mixing Zones

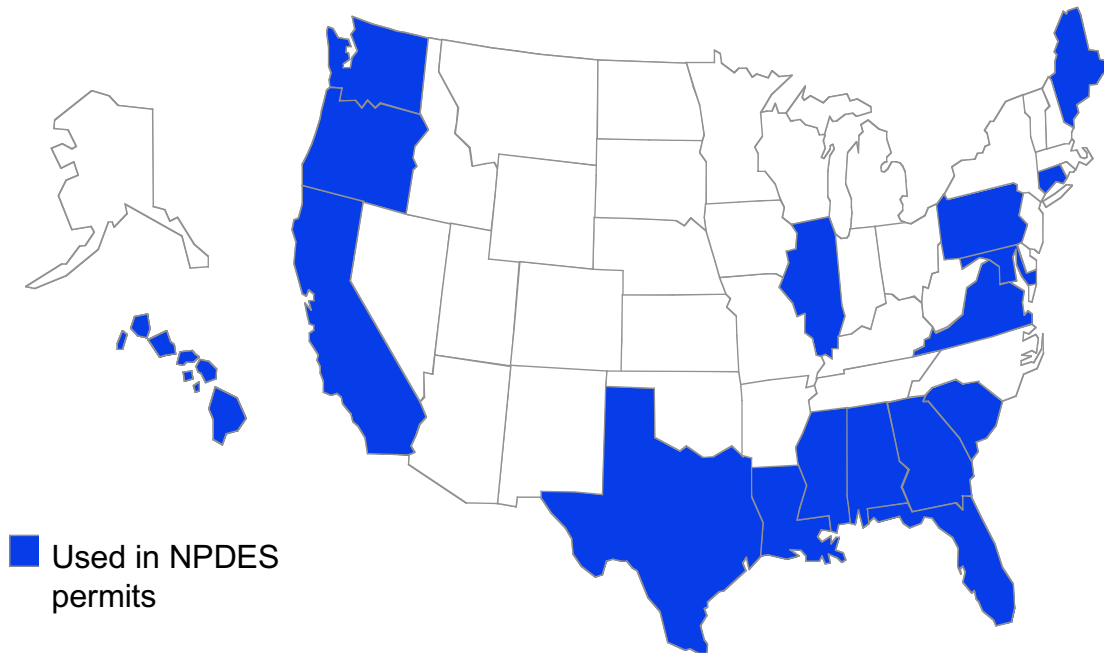
*Allocated impact zones where water quality criteria can be exceeded provided acutely toxic conditions are prevented*





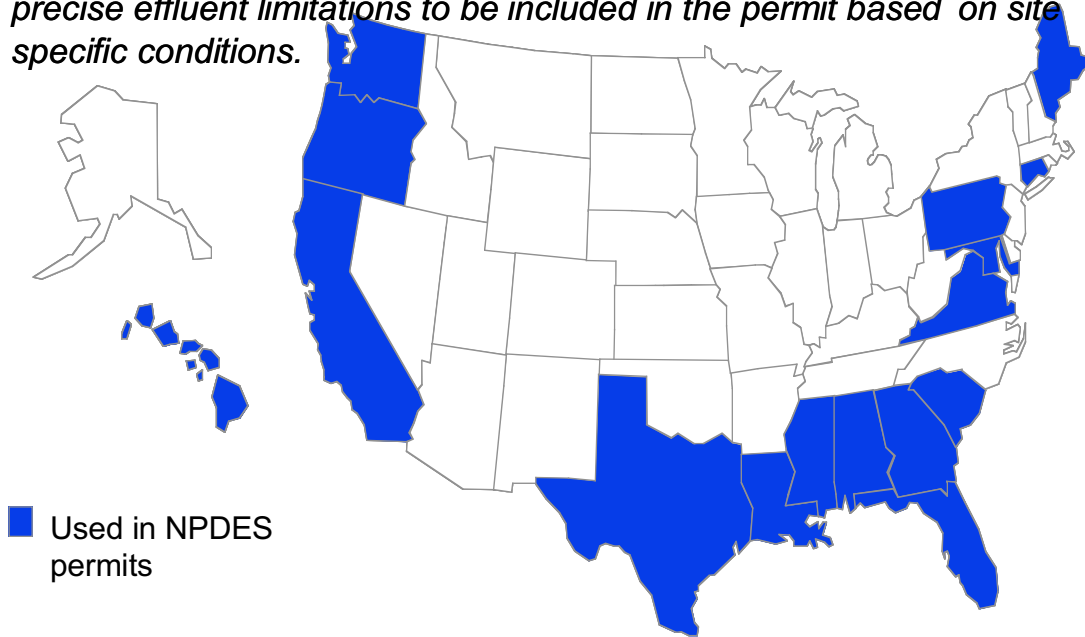
## Best Professional Judgment

*Determination of the precise effluent limitations to be included in the permit based on site specific conditions*



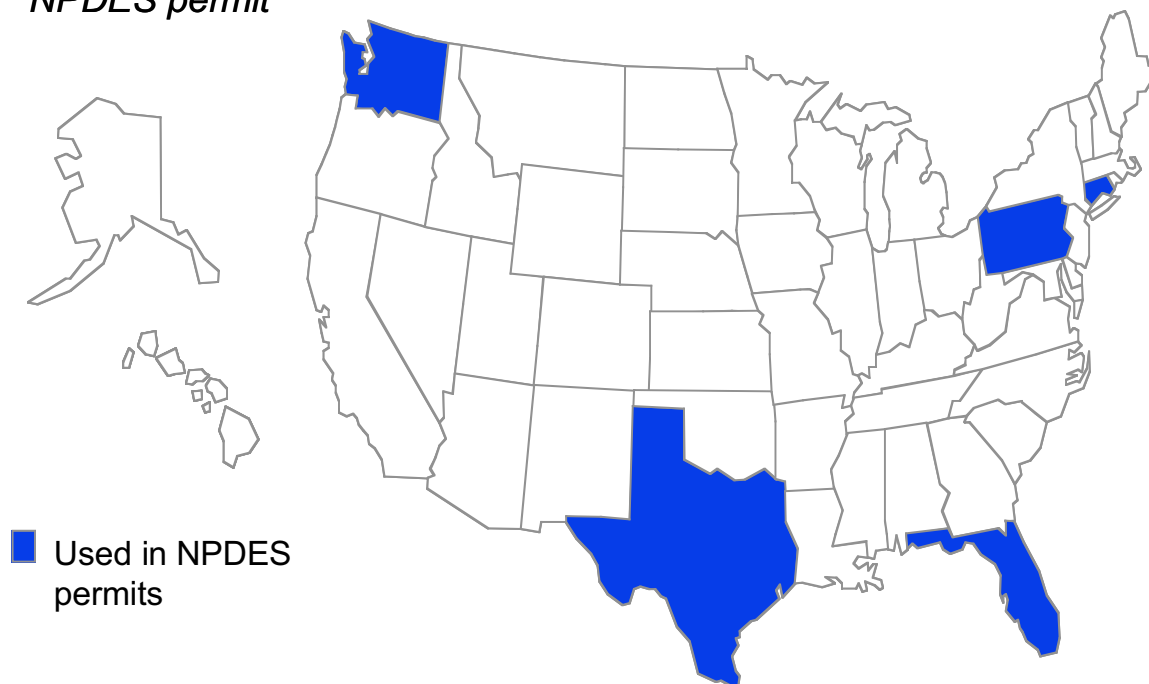
## Best Management Practices (BMPs) & Best Professional Judgment (BPJ)

*BMPs are practical and economical techniques used for control and/or collection of pollutants in shipyards, and BPJ is a determination of the precise effluent limitations to be included in the permit based on site specific conditions.*



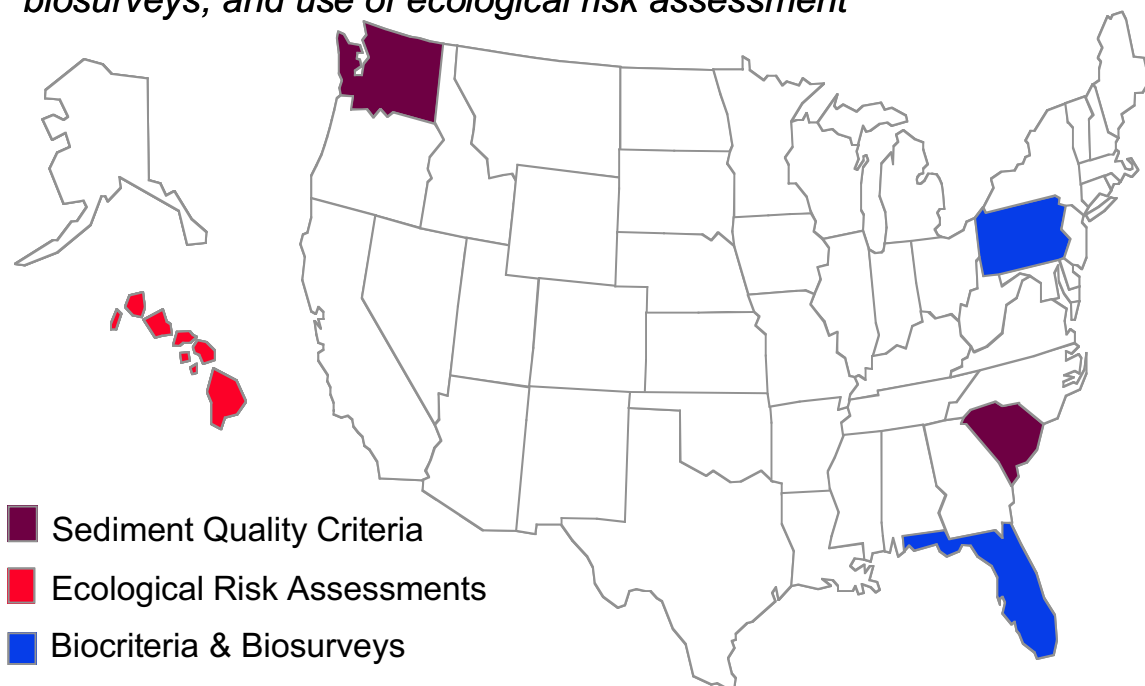
## Pretreatment Standards for POTW

*Standards of treatment for industrial wastewater before it enters public treatment works in order to avoid violating treatment plants NPDES permit*

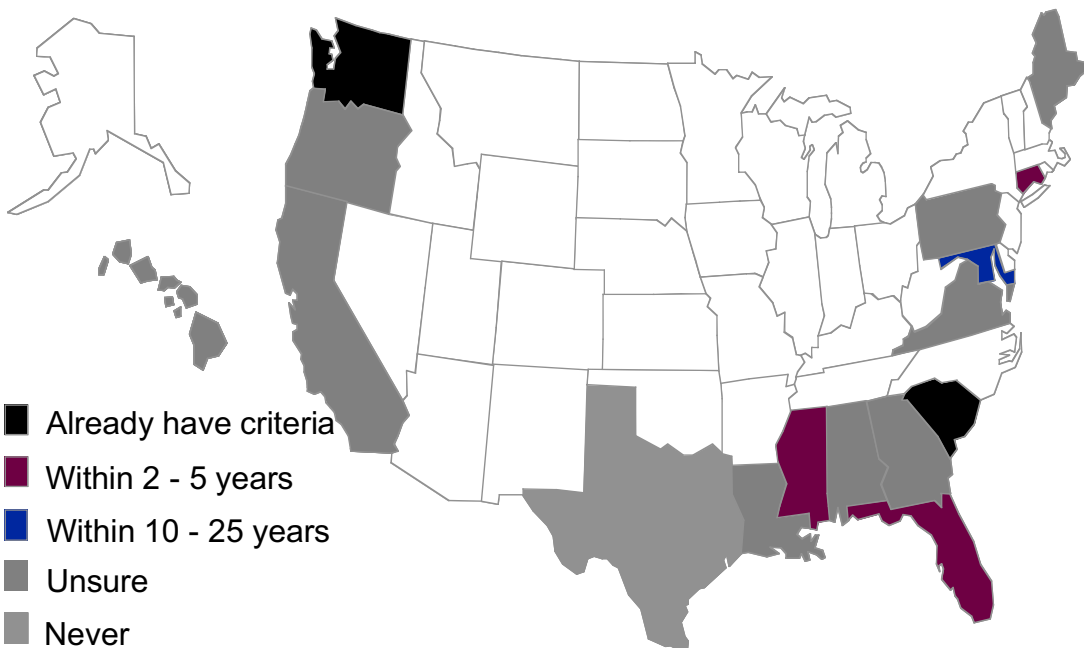


## Various Other Regulatory Approaches

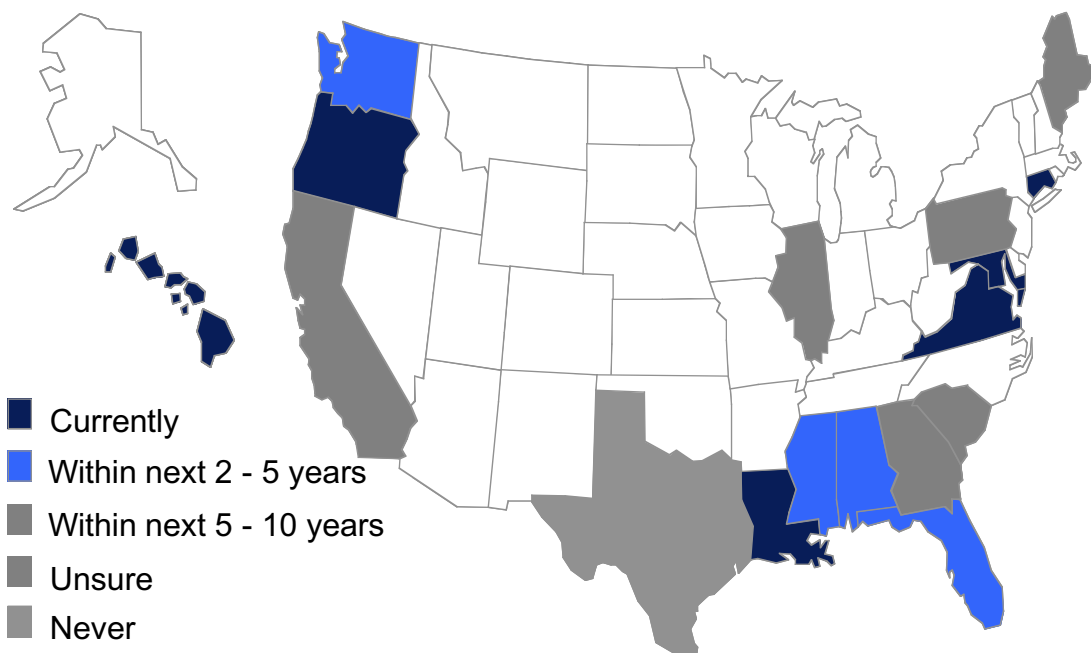
*Numerical sediment criteria for specific chemicals, monitoring of the biological community in receiving water with biocriteria and biosurveys, and use of ecological risk assessment*



## When does your agency expect to promulgate chemical-specific sediment quality criteria?



## When would your agency consider allowing an industry to renegotiate NPDES permit limits based on an ecological risk assessment?



## Survey of State Regulatory Agencies

*All states bordering major water bodies were contacted and all the states with active shipbuilding, boatbuilding, and vessel repair facilities replied to the survey.*



## **APPENDIX B - SHIPYARD SURVEY AND RESULTS**

APPENDIX B from *A Shipyard Program for NPDES Compliance*, NSRP Task N1-95-02, Applied Research Laboratory, State College, PA, July 2000



***A Shipyard Program for NPDES Compliance***  
***N1-95-02***

**Shipyard Survey Summary**

**Prepared by**  
**Michelle L. Won**  
**Won Engineering**

**in cooperation with**  
**National Steel & Shipbuilding Company**

**April 1997**

## **A Shipyard Program for NPDES Compliance, N1-95-02, Shipyard Survey**

### **Introduction**

This Shipyard Survey was conducted as a sub-task of an NSRP project, *A Shipyard Program for NPDES Compliance, N1-95-02*. The mission of the NSRP project is to develop a tool that will assist the shipbuilding industry in NPDS compliance, permitting activities, standard setting, and risk management. The tool will be in a form of ecological risk assessment model. To aid in developing the ecological risk assessment model, shipbuilding and repair facilities were surveyed for current permitting specifics and requirements. This paper presents a summary of the information gathered from surveying eight shipyards across the United States.

### **Methodology**

The objectives of the Shipyard Survey were: to survey current NPDES regulated discharge constituent, concentration, and limitations from a wide cross-section of shipyards in the US; to identify any modeling programs that are currently in use by shipyards or regulatory agencies related to NPDES regulations or ecological risk assessment; and to assess how the gathered information can be integrated into the focused monitoring program model that would result from completion of the project N1-95-02.

The survey was designed by NASSCO to collect information on regulating agency, permit type, limitations (constituents and numerical concentration levels), monitoring requirements, shipyard site specifics including existing monitoring data, pollutant sources, pollutant pathways, etc., and the use of a model for point or non-point source discharges. See Attachment 1 for a copy of the survey form.

Eight public and commercial shipyards from the EPA regions 1, 3, 4, 6, 9, and 10 were contacted for participating in the survey and for releasing a copy of their NPDES or equivalent state permits. Six shipyards participated in the telephone interview. The NPDES permits of the eight shipyards were used for gathering information. Table 1 lists the shipyards that have participated in the survey. A summary of the survey responses from shipyards is presented in Table 2 and 3.

Shipyard Name	EPA Region
Atlantic Marine	4
Avondale	6
Bath Iron Works	1
Electric Boat Corp.	1
Ingalls	4
NASSCO	9
Newport News	3
Puget Sound Naval Shipyard	10

Table 1. Survey Participants

### Results

All eight shipyards' operations require an NPDES or state-equivalent permit. One shipyard's discharges are made of fresh water, and seven shipyards' discharges are made to brackish to salt water. The receiving bodies of water of these shipyards are used for various purposes, including agricultural, industrial, and recreational purposes.

Most of those surveyed felt that the regulating agency used best management practices (BMP) for developing their permit. All six telephone-interviewed shipyards responded that their permits were BMP based. Other commonly used approaches mentioned in the survey included use of chemical specific water quality criteria, federal water quality standards, and state water quality standards. These findings are consistent with the results of the regulatory agency survey conducted by Penn State University as another subtask of the project.

All but one shipyard were required to monitor discharge effluent. Most common permitted shipyard discharges included storm water, dock drainage and dock dewatering water, and non-contact cooling water. Table 2 summarizes the permitted discharges and numerical discharge limits of the eight shipyards. As shown in Table 2, the discharge effluent monitoring requirements vary considerably from shipyard to shipyard. Regulated constituents with numerical limitations included metals (copper, lead, zinc, total chromium, and tributyl tin), residual chlorine, phosphorus, total suspended solids, oil and grease, chemical oxygen demand, and polynuclear aromatic hydrocarbons (PAH). Four shipyards are required to do additional environmental monitoring (e.g., receiving water monitoring, biota studies, sediment monitoring, etc.). See Table 3 for the summary of the environmental monitoring requirements.

Three of the six shipyards participated in the telephone interview responded that the use of a quantitative model has been or will be involved in development of their permits. For one west coast yard in particular, the regulating agency is using collected sediment data, water column data, and toxicity information from the past 15 years to develop the yard's proposed new permit.

All six of the six telephone interviewed shipyards carried out welding, abrasive blasting, and painting operations. All responded a presence of the potential for pollutants from these operations to reach the direct discharge, airborne, and/or surface runoff pathways. All six of the six telephone interviewed shipyards employed handwipe cleaning and vessel cleaning in their operations. Five shipyards responded a presence of the potential for the pollutants from wipe cleaning and vessel cleaning operations to reach the airborne pathway and direct discharge pathway, respectively. All shipyards had various combustion sources such as boilers, compressors, generators, cranes, furnaces, ovens, and cooling towers that would present the potential for the pollutants to reach the pollutant pathways. All six yards responded a presence of the potential for air pollutants from the crane operation to reach the airborne pathway or oil and grease left on the roadway by the cranes to reach the surface runoff pathway.

All six telephone interviewed shipyards had annual training programs that incorporated waste management, storm water management, and best management practices. Four shipyards had additional company newsletters and “talks” with employees to discuss various environmentally related subjects.

### **Conclusion**

At the time of survey, four shipyards were in the process of renegotiating their NPDES permit. Some of the information provided were extracted from the proposed permits rather than the existing permit. The proposed permit for a shipyard in the Region VI stated monitoring for a greater number of metals to a significantly lower discharge limits than the requirements of the previous permit. For a Region IX shipyard, the state regulatory agency emphasized more on prohibiting discharges in the shipyard’s proposed permit rather than specifying monitoring requirements. It was a consensus among these shipyards that the discharge and monitoring requirements were becoming more stringent in their proposed permits. Use of a quantitative modeling by shipyards or agencies was not prevalent; however, many survey participants believed that the use of a quantitative modeling would become beneficial or would be required by the regulating agencies in the future.

**Table 2. NPDES Discharge Limits of The US Shipyards**

	Shipyard 1	Shipyard 2	Shipyard 3	Shipyard 4	Shipyard 5	Shipyard 6	Shipyard 7	Shipyard 8
<i>Permitted Discharges</i>	Numerical Discharge Limits (Only Constituents with Numerical Discharge Limits Are Listed.)							
<b>Fire protection water</b>	None <sup>1</sup>	NA	C12(200ppb)	NA	NA	NA	NA	NA
<b>Shipbuilding Ways Gate Leakage</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Shipbuilding Ways Wall Leakage</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Shipbuilding Ways Flood Water</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Graving Dock Flood Water</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Graving Dock Gate Leakage</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Graving Dock Wall Leakage</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Graving Dock Hydrostatic Relief</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Graving Dock Pipe Test Water</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Floating Drydock Deballast &amp; Emergency Water</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Steam Condensate</b>	TSS(30ppm)	NA	C12(200ppb)	None	NA	o&g(10ppm),TSS(30ppm), C12(0.2ppm),Cr(0.2ppm), Zn(1.0ppm)	NA	NA
<b>Salt Box Discharges</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Pipe &amp; Tank Hydrostatic Test Water</b>	NA	NA	C12(200ppb)	NA	NA	NA	NA	NA
<b>Non-Contact Cooling Water, Salt &amp; Fresh</b>	None <sup>2</sup>	None	C12(200ppb)	None	NA	o&g(10ppm), Cu(0.019ppm)	C12(0.2ppm)	NA
<b>Fresh &amp; Salt Washdowns of Vessels</b>	NA	NA	C12(200ppb)	NA	NA	NA	NA	NA
<b>Misc. Low Volume, Non-Contact Water</b>	NA	NA	NA	NA	NA	NA	NA	NA
<b>Launchway Point Source</b>	Zn(5ppm), o&g(15ppm), COD(100ppm) <sup>3</sup>	NA	NA	NA	NA	NA	NA	NA
<b>Treated Ship Ballast Water</b>	NA	o&g(10ppm), PAH(60ppb)	NA	NA	NA	NA	NA	NA
<b>Stormwater</b>	COD(100ppm), o&g(15ppm) <sup>4</sup>	NA	C12(200ppb)	TBT(0.05ppb)-drydock	o&g(15ppm)	None	None	NA
<b>Boiler Blowdown</b>	TSS (30ppm)	None	Cu(72ppb), Pb(399ppb), o&g (10ppm), C12(200ppb)	NA	NA	NA	NA	NA
<b>Graving Dock, Wetdock &amp; Drydock Dewatering</b>	NA	NA	Cu(72ppb), Pb(399ppb), o&g (10ppm), C12(200ppb)	NA	NA	NA	NA	NA
<b>Drydock Drainage</b>	NA	NA	NA	Phosphorus(2.0ppm), Cu(490ppb), Pb(335ppb), TBT(0.05ppb)	NA	o&g(10ppm)Cu(0.019ppm)	NA	NA
<b>Treated Steam Plant Wastewater</b>	NA	NA	NA	NA	NA	o&g(10ppm), TSS(30ppm), C12(0.2ppm), Cr(0.2ppm), Zn(1.0ppm)	NA	NA
<b>Cooling Tower Blowdown</b>	NA <sup>5</sup>	NA	NA	NA	NA	NA	Cr(0.2ppm), Zn(0.2ppm), C12(0.2ppm)	NA
<b>Treated Bilge Water</b>	NA	NA	NA	NA	NA	NA	o&g(10ppm), TSS(30ppm), Cr(0.4ppm), Zn(0.4ppm)	NA
NA = Not Applicable.			3. Proposed Req't: Requirements deleted.					
None = Monitoring required but no specified numerical discharge limits.			4. Proposed Req't: Add Cd 0.1, Cr 0.15, Cu 0.15, Pb 0.1, Zn 1.0, all in ppm.					
1. Proposed Req't: Change to TSS 50, COD 50, all in ppm.			5. Proposed Req't: Change to TSS 50, o&g 15, Cd 0.025, Cr 0.075, Cu 0.05, Pb 0.25, Zn 0.5, all in ppm.					
2. Proposed Req't: Change to TSS 50, o&g 15, all in ppm.								

**Table 3. Summary of Environmental Monitoring Requirements**

	Shipyard 1	Shipyard 2	Shipyard 3	Shipyard 4	Shipyard 5	Shipyard 6	Shipyard 7	Shipyard 8
Monitoring Descriptions	Environmental Monitoring Requirements							
<b>Whole Effluent Toxicity Testing</b>			Dock dewatering water, non-contact cooling water, boiler blowdown, boiler feedwater & condensate, and R&D test tank water	Drydock drainage from drydocks and shipways, non-contact cooling water, air conditioner blowdown, pipeshop rinse, and storm water		Drydock drainage, non-contact cooling water, & treated steam plant wastewater		
<i>Acute Tests</i>	NA	NA	48-hr static test using Invertebrate (neonatal Mysidopsis bahia) & Vertebrate (larval Cyprinodon variegatus)	48-hr static test using Invertebrate (neonatal Mysidopsis bahia) & Vertebrate (larval Cyprinodon variegatus)	NA	96-hr static renewal or flow-through test using Silverside Minnow (Menidia beryllina) or Mysid Shrimp (Mysidopsis bahia)	NA	NA
<i>Chronic Tests</i>	NA	NA	NA	NA	NA	Using one of the following: Sand dollar; Green, purple or red sea urchin; Pacific oyster; or Bay mussel	NA	NA
<i>Sediment Monitoring</i>	NA	NA	NA	NA	NA	Required by WA Dept of Ecology, Toxic Cleanup Program and EPA Superfund Program	NA	Ar, Cd, Cr, Cu, Pb, Hg, Ni, Ag, Zn, TBT, PCB/PCT, PAH, TOC, TPH, and paint chip analysis for metals and TBT

## Attachment 1

Facility Name \_\_\_\_\_

**A SHIPYARD PROGRAM FOR NPDES COMPLIANCE**  
**N1-95-02**  
**Shipyard Survey**

**INSTRUCTIONS:** Please answer all survey questions. Fax or mail the completed survey to : NASSCO

Attn: Michelle Won  
P.O. Box 85278  
MS 22-A  
San Diego, CA 92186-5278  
FAX 619-232-6411

**Part A. General Facility Information**

1. Date of Completion of the Questionnaire: \_\_\_\_\_
2. Facility Name: \_\_\_\_\_
3. Address: \_\_\_\_\_  
\_\_\_\_\_
4. Questionnaire Completed by: \_\_\_\_\_
5. Telephone No.: \_\_\_\_\_ Fax: \_\_\_\_\_
6. Approximate Number of Employees at This Facility: \_\_\_\_\_
7. Size of Shipyard:
  - a. Land Area \_\_\_\_\_
  - b. Waterfront \_\_\_\_\_
8. Please Provide a Diagram of Your Facility
9. Number & Locations of NPDES Permitted Discharge Points: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_
10. Number & Locations of Storm Water Outfalls: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**Part B. Body of Water**

1. Name of Receiving Body of Water: \_\_\_\_\_
2. Salinity, if known: \_\_\_\_\_
3. Depth, if known: \_\_\_\_\_
4. Temperature, if known: \_\_\_\_\_
5. Current Speed, if known: \_\_\_\_\_
6. Any Additional Information: \_\_\_\_\_  
\_\_\_\_\_



Facility Name \_\_\_\_\_

**Part C. NPDES Permit or Equivalent**

1. Does Your Facility Require an NPDES Permit or Equivalent State Permit? \_\_\_\_\_

*If “Yes”, Please Provide a Copy of Your NPDES Permit*

2. Regulatory Agency: \_\_\_\_\_

3. What Approaches Were Used to Develop Your Permit? Please ‘√’ all applicable.

- a. Best Management Practice (BMP) \_\_\_\_\_
- b. Chemical-Specific Water Quality Criteria \_\_\_\_\_
- c. Chemical-Specific Sediment Quality Criteria \_\_\_\_\_
- d. Whole Effluent Toxicity \_\_\_\_\_
- e. Effluent Monitoring \_\_\_\_\_
- f. Receiving Water Biological Assessment \_\_\_\_\_
- g. Federal Standards for the Shipyard Industry \_\_\_\_\_
- h. Federal Water Quality Standards \_\_\_\_\_
- i. State Water Quality Standards \_\_\_\_\_

4. Permit Structure

- a. Is BMP Plan Required? \_\_\_\_\_
- b. Is Effluent Monitoring Required? \_\_\_\_\_

If “Yes”, What Are Regulated Constituents and Their Limits?

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- c. Is Environmental Monitoring (e.g., Receiving Water Monitoring, Biota Studies, etc.) Required? \_\_\_\_\_

If “Yes”, Please Specify: \_\_\_\_\_

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Facility Name \_\_\_\_\_

- d. Is Sediment Monitoring Required? \_\_\_\_\_  
If "Yes", Please Specify:

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5. Modeling

- a. Did/Does Your Facility Use Any Kind of Quantitative Model in the Development of Your NPDES or Equivalent Permit? \_\_\_\_\_  
If "Yes", Please Specify:

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- b. Did/Does the Regulating Agency Use a Quantitative Model in The Development of Your NPDES or Equivalent Permit? \_\_\_\_\_  
If "Yes", Please Specify:

---

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**Part D. Shipyard Processes & Material Usage**

**Please '✓' the operations that are carried out at your facility.**

1. Welding

Potential for Reaching Pollutant Pathways? Please '✓' all applicable.

- a. Direct Discharge Pathway  
b. Airborne Pathway  
c. Surface Runoff Pathway

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2. Abrasive Blasting

Potential for Reaching Pollutant Pathways? Please '✓' all applicable.

- a. Direct Discharge Pathway  
b. Airborne Pathway  
c. Surface Runoff Pathway

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---

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Facility Name \_\_\_\_\_

3. Painting \_\_\_\_\_  
Potential for Reaching Pollutant Pathways? Please '√' all applicable.  
a. Direct Discharge Pathway \_\_\_\_\_  
b. Airborne Pathway \_\_\_\_\_  
c. Surface Runoff Pathway \_\_\_\_\_
4. Plating & Surface Treatment Operations \_\_\_\_\_  
Potential for Reaching Pollutant Pathways? Please '√' all applicable.  
a. Direct Discharge Pathway \_\_\_\_\_  
b. Airborne Pathway \_\_\_\_\_  
c. Surface Runoff Pathway \_\_\_\_\_
5. Cleaning Operation \_\_\_\_\_  
a. Hand Wiping \_\_\_\_\_  
Potential for Reaching Pollutant Pathways? Please '√' all applicable.  
1) Direct Discharge Pathway \_\_\_\_\_  
2) Airborne Pathway \_\_\_\_\_  
3) Surface Runoff Pathway \_\_\_\_\_
- b. Ultrasonic Cleaning \_\_\_\_\_  
Potential for Reaching Pollutant Pathways? Please '√' all applicable.  
1) Direct Discharge Pathway \_\_\_\_\_  
2) Airborne Pathway \_\_\_\_\_  
3) Surface Runoff Pathway \_\_\_\_\_
- c. Steam Gun Stripping \_\_\_\_\_  
Potential for Reaching Pollutant Pathways? Please '√' all applicable.  
1) Direct Discharge Pathway \_\_\_\_\_  
2) Airborne Pathway \_\_\_\_\_  
3) Surface Runoff Pathway \_\_\_\_\_
- d. Vapor Phase Cleaning \_\_\_\_\_  
Potential for Reaching Pollutant Pathways? Please '√' all applicable.  
1) Direct Discharge Pathway \_\_\_\_\_  
2) Airborne Pathway \_\_\_\_\_  
3) Surface Runoff Pathway \_\_\_\_\_
- e. Vessel Cleaning \_\_\_\_\_  
Potential for Reaching Pollutant Pathways? Please '√' all applicable.  
1) Direct Discharge Pathway \_\_\_\_\_  
4) Airborne Pathway \_\_\_\_\_  
2) Surface Runoff Pathway \_\_\_\_\_

Facility Name \_\_\_\_\_

f. Other, Please Specify \_\_\_\_\_

\_\_\_\_\_

6. Combustion Sources

a. Boilers

Potential for Reaching Pollutant Pathways? Please '√' all applicable.

1) Direct Discharge Pathway \_\_\_\_\_

2) Airborne Pathway \_\_\_\_\_

3) Surface Runoff Pathway \_\_\_\_\_

b. Compressors

Potential for Reaching Pollutant Pathways? Please '√' all applicable.

1) Direct Discharge Pathway \_\_\_\_\_

2) Airborne Pathway \_\_\_\_\_

3) Surface Runoff Pathway \_\_\_\_\_

c. Generators

Potential for Reaching Pollutant Pathways? Please '√' all applicable.

1) Direct Discharge Pathway \_\_\_\_\_

2) Airborne Pathway \_\_\_\_\_

3) Surface Runoff Pathway \_\_\_\_\_

d. Cranes

Potential for Reaching Pollutant Pathways? Please '√' all applicable.

1) Direct Discharge Pathway \_\_\_\_\_

2) Airborne Pathway \_\_\_\_\_

3) Surface Runoff Pathway \_\_\_\_\_

e. Furnaces/Ovens

Potential for Reaching Pollutant Pathways? Please '√' all applicable.

1) Direct Discharge Pathway \_\_\_\_\_

2) Airborne Pathway \_\_\_\_\_

3) Surface Runoff Pathway \_\_\_\_\_

f. Cooling Towers

Potential for Reaching Pollutant Pathways? Please '√' all applicable.

1) Direct Discharge Pathway \_\_\_\_\_

2) Airborne Pathway \_\_\_\_\_

3) Surface Runoff Pathway \_\_\_\_\_

g. Other, Please Specify \_\_\_\_\_

\_\_\_\_\_

Facility Name \_\_\_\_\_

## Part E. Human Factor

- |   |                                 |
|---|---------------------------------|
| 1. Trade Personnel Turnover Rate, if available: |                                 |
| 2. Employee Training                            |                                 |
| <u>Description</u>                              | <u>Frequency &amp; Duration</u> |
| a. HAZCOM                                       |                                 |
| b. Waste Management                             |                                 |
| c. Storm Water Management                       |                                 |
| d. Best Management Practices                    |                                 |
| e. Other, Please Specify                        |                                 |
|   |                                 |
|   |                                 |
|   |                                 |

### Additional Comments

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page. There are no margins, text, or other markings on the paper.

**APPENDIX C**  
**MEDLEY USER'S MANUAL**  
for A Shipyard Program for NPDES Compliance

Linking and providing user-friendly access to the incorporated models:

1. PSRM-QUAL
2. B.E.S.T.
3. ECORISK

Developed at  
The Applied Research Laboratory  
and The Pennsylvania State University

May, 2000

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Major contributions to this manual, on the PSRM-QUAL module in particular, were provided by:

## 1.0 INTRODUCTION

Three modeling programs were developed to aid facilities in determining and reducing the risk posed by their facility activities on the organisms within an adjacent body of water. **PSRM-QUAL** calculates the flow and concentration of pollutants from a facility into a body of water over time; **B.E.S.T.** predicts the dispersion of those pollutants throughout a body of water and into its sediment; **ECORISK** predicts the risk of the pollutants to organisms living in the body of water and in its sediment. **MEDLEY** is a fourth program, a user-interface that has been developed to link the three modeling programs and to make data and file manipulations easier for the user.

In this brief User's Manual the user is provided with a quick overview to allow adequate understanding of each model to allow immediate use of the program. In addition a tutorial has been included which takes the user through all steps of the MEDLEY interface, viewing each form, demonstrating entry of data and file selection, and running of all three technical models. For further information, the original **PSRM-QUAL** User's Manual and the complete **B.E.S.T.** documentation are attached as Appendix F and Appendix G, respectively. As the reader's familiarity with the three models increases and the need for more advanced modeling features are required (e.g., inclusion of effect of BMPs on runoff quality or the selection of different nodes within the bay), the original **PSRM-QUAL** User's Manual and the complete **B.E.S.T.** documentation will be required.



## 2.0 MODULE OVERVIEWS

### 2.1 MEDLEY

**MEDLEY** is a Visual Basic program developed to link the **PSRM-QUAL**, **B.E.S.T.** and **ECORISK** modeling programs, and to perform many complex data manipulations, data and file conversions and formatting tasks. As shown in Figure 1, **MEDLEY** provides the main menu from which to run all of the technical NPDES modeling programs. It also performs many tasks that would otherwise require many hours of manual data manipulation.

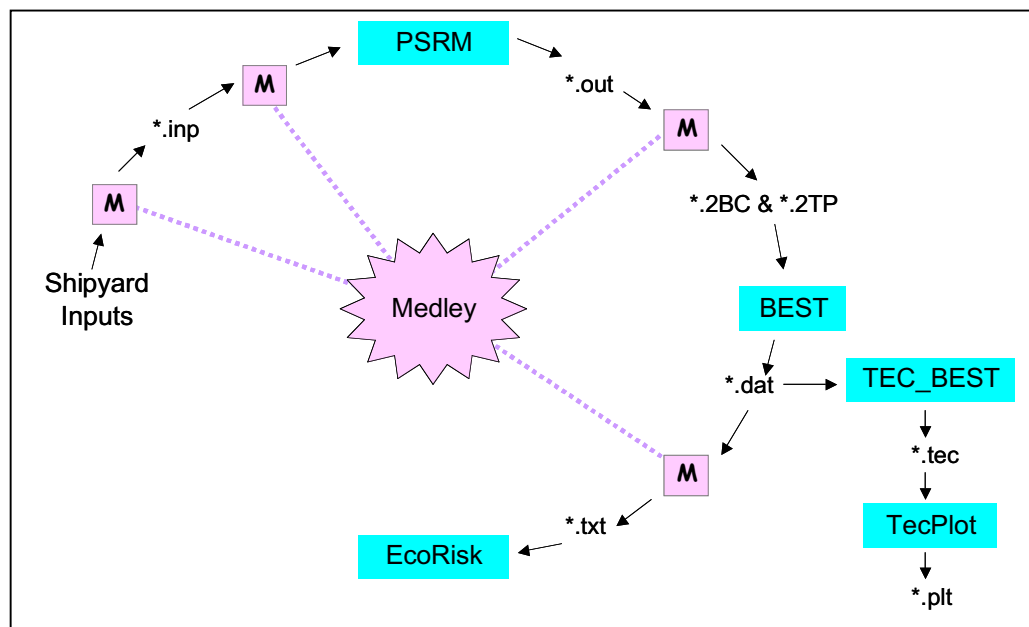


Figure 1. **MEDLEY**/NPDES model interrelationships.

### 2.2 PSRM-QUAL

The Penn State Runoff Quality Model (**PSRM-QUAL**) was developed in 1995 for the Pennsylvania Department of Environmental Protection to characterize contaminants in urban runoff. This program can effectively model the transport of contaminants suspended in a flowing liquid – analogous to sediments being disturbed and transported via a storm event at an industrial facility. This model

was chosen for the current NSRP project for several reasons – it is accurate, relatively simple to operate, accepted by a state regulatory agency, and better suited for impermeable surface flow than other storm water models that were considered.

**PSRM-QUAL** is a Microsoft Quick BASIC computer program that calculates hydrographs and pollutographs for a specific watershed associated with a specific storm event. The model works best for an impermeable watershed (e.g., paved parking lot). As adapted for this project, the **PSRM-QUAL** model will be run for each discrete drainage area within a site for each rain event. For a site with multiple outfalls (e.g.,  $n$ ) which drain  $n$  subareas, **PSRM-QUAL** should be run  $n$  times for each storm event. To model storm water inputs for a whole season or year (e.g.,  $m$  storm events over a 6-month period), **PSRM-QUAL** would have to be run a total of  $n \times m$  times. Because of the potentially large number of input and output data files required for a long-term simulation, a careful system for naming files should be maintained (Section 3.0 Data File Naming Structure).

The goal of the **PSRM-QUAL** portion of this software package is to create hydrographs and pollutographs that serve as input loadings to the Bay/Estuary Hydrodynamics and Sediment/Contaminant Transport (**B.E.S.T.**) model. Shipyard data relevant for each outfall (e.g., drainage area, primary industrial activity, area, slope, etc.) and storm event (e.g., duration, amount) are the required inputs to the **PSRM-QUAL** model. The input file created using **MEDLEY** contains all of the information needed by the program to perform the modeling calculations. The majority of input parameters are default values (described in the original User's Manual in Appendix F). However, the input file contains specific information to describe both the drainage area and the storm event. The tutorial example described in Section 4.0 leads the user through every input parameter required to run **PSRM-QUAL**.

After an input file has been created, named and saved, **PSRM-QUAL** runs to create the corresponding output file. The output file contains data for time, runoff flow rate, total suspended solids, and total copper (Cu) concentration. **MEDLEY** manipulates this data and converts it into the proper units and formats for use in the **B.E.S.T.** model.

### **2.3 B.E.S.T.**

**B.E.S.T.** is a numerical model of Bay/Estuary Hydrodynamics and Sediment/Contaminant Transport. This model is a 2-D depth-averaged numerical model simulating water flow and reactive contaminant and sediment transport in bay/estuary systems. This model includes two computational modules: flow and transport. The model is relatively complex and includes calculations to compute circulation and eddy fluxes, to compute the migration of sediments and contaminants, sediments suspended in the water column or deposited on bed rock, contaminants in the dissolved phase in the water column or in the interstitial water of the bed sediments, chemical reactions, including aqueous complexation, adsorption/desorption, and volatilization. Details and four examples that demonstrate the capability of this model are included in Appendix F.

In order to run the **B.E.S.T.** model calculations using **MEDLEY**, it is only necessary to select the appropriate data files from those run using **PSRM-QUAL** and initiate the running of the model. This model took about 60 hours to run on a desktop computer with the following hardware: 600MHZ Pentium III, 256MB 100MHZ RAM, 20GB type EIDE disk, L2 CACHE 512KB. The program runs in the background allowing the user to perform normal daily functions on the computer at the same time.

The **B.E.S.T.** model as included in this **MEDLEY** package is configured to specifically address the NASSCO shipyard in San Diego Bay, and on copper as the contaminant. In order to run the **B.E.S.T.** model/simulation for other locations

in San Diego Bay, it is necessary to select different nodes within the bay grid (Section 5.2). In order to adapt this model for other contaminants, a programmer would have to build the specific chemical reactivity and adsorption data for the desired chemical into the model. Finally, in order to adapt this model to other bodies of water, a programmer would have to replace the San Diego Bay bathymetry and tidal data with that of the desired body of water.

## 2.4 ECORISK

The **ECORISK** model uses the contaminant concentrations and dispersion data generated by the **B.E.S.T.** model, together with copper risk criteria (LC50) for any particular resident species of interest, to calculate the risk of exposure for the given species to copper concentrations above its LC50 over all or part of the bay. Risks of exposure to either acute or chronic LC50 concentrations can be calculated, and these can be based on copper concentrations that are averaged over time, space, or overall. Additional species can easily be added and saved to the model database simply by typing in the name of the species, its location within the bay, and its acute and chronic copper LC50 values.

**ECORISK** calculates risk, based on the Tier 2 method presented by the Water Environment Research Foundation in *Aquatic Ecological Risk Assessment: A Multi-Tiered Approach* (Project 91-AER-1, 1996). The Tier 2 method estimates risk by comparing the mean and standard deviation of the Expected Environmental Concentration (EEC) to the mean and standard deviation of the Environmental Risk Criteria (ERC). **ECORISK** is calculated in the same way, utilizing the B.E.S.T.-generated copper concentrations as the Expected Environmental Concentration and the LC50 found in the literature as the Environmental Risk Criteria .

Once the **B.E.S.T.** calculations have been run, **MEDLEY** is used to select the appropriate data files and then to initiate the **ECORISK** module. Execution of this module is easily understood, using a familiar Windows type access panel.

### 3.0 DATA FILE NAMING STRUCTURE

The **PSRM-QUAL** part of this simulation package takes shipyard and rainfall data and calculates hydrographs and pollutographs for a specific watershed associated with a specific storm event. The model, as applied here, is run once for each subarea (drainage area) for each rain event. Thus, for a site with multiple outfalls (e.g.,  $n$ ) which drain  $n$  subareas, **PSRM-QUAL** should be run  $n$  times for each storm event. To model storm water inputs for a whole month, season or year (e.g.,  $m$  storm events over a 6-month period), **PSRM-QUAL** would have to be run a total of  $n \times m$  times. Because of the potentially large number of input and output data files required for a long-term simulation, a careful system for naming files should be maintained.

Two types of data are required in order to run **PSRM-QUAL**: drainage area data, and rainfall data.

Drainage area data: Each stormwater drainage area within the facility should be identified. For each drainage area, you must determine the land use which best matches the shipyard activities that take place within the drainage area, the Land Use Index (see Section 5.0), the surface area and the slope of the drainage area, and the fraction of the area that is impervious. In addition, sediment amounts and the Fraction of Copper ( $F_{Cu}$ ) within the suspended solids (g Cu/100 g TSS), for each of the different Land Use Indexes must be known from previous testing. (See Section 5.0 for more information on how to determine these numbers).

Once this information is determined, each drainage area should be “matched” to the best possible Node as identified in the **B.E.S.T.** model. This is illustrated in Figure 2 below.

Rainfall data: For each rain event to be included in the simulation, data on the number of inches of stormwater per unit time are required. For the NASSCO simulation, these storm event characteristics were obtained by purchasing 15-minute rain gage data for a rain gage maintained by NOAA at Lindbergh Field, San Diego, CA. However, a recording rain gage at the facility being modeled would provide similar information.

The data for each rain event for each Node must be identified by separate file names. One suggested way of doing this is to name the files with the node number followed by the rain event number as shown in Figure 2 below. In this example, the data for Drainage Area 1 has been assigned to Node 602. Thus for rain event 1, the data file name is 602\_1. There are 3 drainage areas, with two rain events each; **PSRM-QUAL** will have to be run 6 times (n x m, or 3 x 2), and there will be 6 output files as indicated in Figure 2.

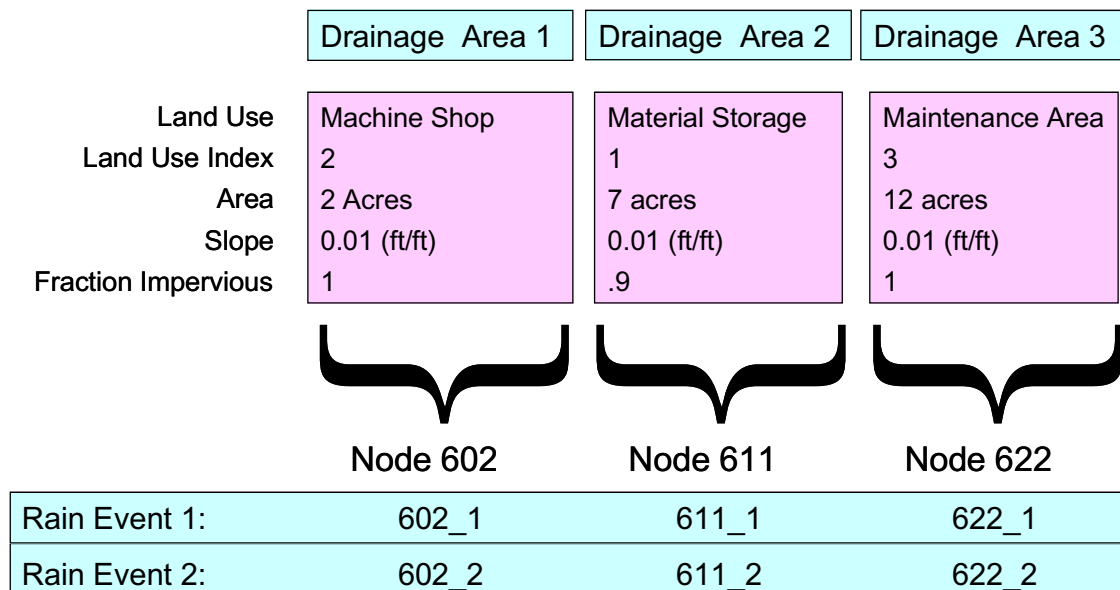


Figure 2. Suggested strategy for naming of **PSRM-QUAL** data files in **MEDLEY**.

Two tables of sample data for two rain events to be used in going through this tutorial are presented in TABLE 1 and TABLE 2 at the end of the tutorial.

## 4.0 MEDLEY TUTORIAL

The purpose of this section is to use an example to show the user how to operate the model in a step-by-step format.

### 4.1 LOADING THE SOFTWARE

Insert the zip disk labeled **MEDLEY Program Disk** in your zip drive. Select **File Manager** or **Explore** from the **Start** menu on your computer or click on the **My Computer** icon on your Desktop. Navigate to and select the Zip directory (usually called Removable Disk) to view its contents, then double click on the **SetupMedley** file. Follow the set-up instructions on the screens that follow. A folder called **Medley** will be set up at the location you select and a **MEDLEY** icon will appear on your desktop.

**NOTE:** You will see a file called **SetupMedley** and a file called **SetupMedleywithsource**. If you are going to run the software only as currently programmed, then select **SetupMedley**. If you are a programmer who intends to get into the source code and modify the program to include other bodies of water or other pollutants, for example, then select **SetupMedleywithsource**.

### 4.2 STARTING MEDLEY

Before starting MEDLEY, you will want to create a folder where all the files for a particular data set can be stored. Select **File Manager** or **Explore** from the **Start** menu on your computer or click on the **My Computer** icon on your Desktop. Navigate to the location where **MEDLEY** is installed. Under the **MEDLEY** folder, create a new folder called **Tutorial**.





Start **MEDLEY** by double clicking on the **MEDLEY** icon on the computer desktop, or by selecting **MEDLEY** from the Programs selection under the Start button on your computer. The following form will appear:

**\* MEDLEY \***

*PENN STATE RUNOFF QUALITY MODEL*

*B.E.S.T*

*EcoRisk*

Select an option

Create a PSRMQ Input file, POLC.DAT file and Output file.	<input type="button" value="PSRMQ"/>
Select PSRMQ Output files to use to create data files for the BEST module.	<input type="button" value="Data Collection"/>
Run the BEST module against data files.	<input type="button" value="Run B.E.S.T."/>
Run Ecorisk against BEST data.	<input type="button" value="Run EcoRisk"/>

\*\*\*\*\*  
(c) 2000 The Pennsylvania State University Applied Research Laboratory  
MEDLEY, PSRMQ, BEST, ECORISK  
\*\*\*\*\*

This screen allows the selection of one of four options:

1. **PSRMQ**, which allows the user to input shipyard pollutant and rain event data into input files, and which then runs the **PSRM-QUAL** model and converts the

**PSRM-QUAL** output into files of the proper format for input into the **B.E.S.T.** model.

2. **Data Collection**, which allows the user to select PSRM-QUAL output files desired for running a **B.E.S.T.** model simulation. This section also allows the user to define rain event start times and dates for use in the **B.E.S.T.** model simulation.
3. **Run B.E.S.T.**, which allows the user to execute the **B.E.S.T.** model computations.
4. **Run ECORISK**, which allows the user to use the output from the **B.E.S.T.** simulation to calculate risks to individual organisms within the water body.

#### **4.3 PSRM-QUAL**

Click on the **PSRQM** button. The following form will appear:

**PSRM-QUAL: FILE CREATE ROUTINE**

Base Directory

E:\

MEDLEY

Tutorial

e:

Directory Name

Input File Name

E:\MEDLEY\tutorial\602\_1\EVENT.INP

Output File Name

E:\MEDLEY\tutorial\602\_1\EVENT.OUT

POLC File Name

E:\MEDLEY\tutorial\602\_1\POLC.DAT

Description (5 lines)

Cancel

Next -->

“MEDLEY” is the default Base directory where all data files will be stored. This is selected automatically for you. The folder “Tutorial” was created above in Section 4.2 to contain the data files for this tutorial.

In the **Directory Name** text box, type in the file name for the data set that is about to be entered. Use the file structure guidelines in Section 3.0 to select an appropriate file name. The file names for the Input files, Output files and POLC file that will be generated by the **PSRM-QUAL** model will be assigned automatically based on the directory and file names you select. These file names are listed on this screen, directly below the **Directory Name** text box.

For the purpose of this tutorial, for this Node and Rain Event, type in the file name 602\_1. (Two tables of sample data for two rain events to be used in going through this tutorial are presented in TABLE 1 and TABLE 2 at the end of the tutorial).

Click on the **Next** button. The following form will appear:

**Time Parameters**

Enter the primary time parameters for all storms  
...

Kinematic wave time interval (minutes)	...	KWTI	<input type="text" value="1"/>
Hydrograph (print) time interval (minutes)	...	HYDTI	<input type="text" value="10"/>
Rainfall time interval is equal to HYDTI (minutes)	...	RFTI	<input type="text"/>
Inter-event time interval (minutes)	...	IETI	<input type="text"/>
Single Storm: Number of points in hydrograph	...	HYDNPT	<input type="text" value="12"/>

Kinematic wave time interval (KWTI) (minutes) – type “1” in the data entry box. A 1-minute KWTI is the suggested value from the original User’s Manual.

Hydrograph time interval (HYDTI) (minutes) – type “10” in the data entry box.

This value is the time interval for which the rainfall amounts have been recorded. This value is also used as the time interval for generating the output. For this example, the total rainfall will be 0.95 inches accumulated over a 1-hour period. Six rainfall amounts (60 minutes total time @ 10 minute HYDTI) will later be required input.

Number of points on hydrograph (HYDNPT) – type “12” and then press “Enter.”

This is the number of intervals displayed on the hydrograph. For a 60-minute storm event, a hydrograph of at least 120 minutes will be required to capture all delayed runoff (12 intervals @ HYDTI).

Click on the **Next** button. The following form will appear:

RAINFALL PARAMETERS: Recording Rain Gage Data

Rain gage name (20 characters max) . . . . . RGNAME\$

X coordinate of rain gage (-9999 to +9999) . . . . . XRG

Y coordinate of rain gage (-9999 to +9999) . . . . . YRG

Rainfall number of points . . . . . RFNPT

Rain gage start time, w.r.t. HYDST (minutes) . . . . . RGST

Enter Rainfall Amounts

Rainfall Poir	Rain amount(inches)
1	.1
2	.2
3	.3
4	.2
5	.1
6	.05

Rain gage name (RGNAME\$) – type “1”. The specific name of the rain gage is not critical for single subarea simulations.

X Coordinate of rain gage (XRG) – type “500”. The specific location of the rain gage is not critical for single subarea simulations.

Y Coordinate of rain gage (YRG) – type “500”.

Rainfall number of points (RFNPT) – type “6”. This is the number of intervals that the storm event has been recorded in, and will occur within the model.

RFNPT and HYDTI (e.g., 10 minutes, entered on the last page) must be in agreement to properly specify the length of the storm (i.e., (RFNPT) x (HYDTI) = duration of storm event).

Rain gage start time (RGST) – leave this set at the default value of “0”.

Enter the 6 (value of RFNPT) rainfall amounts – type “0.1, 0.2, 0.3, 0.2, 0.1, 0.05” in the rainfall amounts table. These are the amounts of rainfall for each 10-minute interval.

Click on the **Next** button. The following form will appear:

Standard Parameters		
<b>Overland and Channel Routing</b>		
Overland flow Manning's n, impervious areas . . .	STDMN1	0.04
Overland flow Manning's n, pervious areas . . .	STDMN2	0.24
Overland flow sinuosity factor . . . . .	STDSF	1.25
Muskingum channel routing X coefficient . . . .	STDMX	0.25
Channel to surface velocity ratio . . . . .	STDCTS	1.5
<b>Rainfall Losses</b>		
Curve number for impervious areas . . . . .	STDCN1	98
Curve number for pervious areas . . . . .	STDCN2	70
Initial abstraction factor . . . . .	STDIAF	0.1
Depression storage, impervious areas (inches) .	STDDS1	0.06
Depression storage, pervious areas (inches) . .	STDDS2	0
Saturated hydraulic conductivity (in/hr) . . . .	STDKS	0.33
Initial fraction of soil capacity wetted . . . .	STDIFSW	0.2
Land use index (1-4) . . . . .	STDLU	3
Maximum sediment load (grams/curb-meter) . . .	STDMSL	380
Initial sediment load (grams/curb-meter) . . .	STDISL	300
Sweeping start time (hours) . . . . .	STDWST	0
Sweeping time interval (days) . . . . .	STDWTI	0
Sweeping fraction removed . . . . .	STDWFR	0
Universal Soil Loss factor K . . . . .	STDUK	0.2
Universal Soil Loss factor C . . . . .	STDUC	0.03
Universal Soil Loss factor P . . . . .	STDUP	0.4
Sartor-Boyd K value (1/inch) . . . . .	STDSBK	6
Coefficient of drag . . . . .	STDCD	0.4
Dynamic friction coefficient . . . . .	STDDFC	0.2
Static friction coefficient . . . . .	STDSCF	0.4
Next -->		

This screen displays current standard **default** parameters used in the PSRMQ model calculations. Any of these **default** parameters can be modified on this screen if desired. Generally the defaults will remain unchanged, and you will simply move to the next screen. The value of any of these parameters for an individual rain event or location can be edited on the next screen, leaving the defaults unchanged.

Review the default “Overland and Channel Routing” parameters. All of the values displayed are the default values for **PSRM-QUAL**. Make no changes at this time.

Review the default “Rainfall Losses”. All of the values displayed are the default values for **PSRM-QUAL**. Make no changes at this time.

Review the default values for the parameters beginning with “Land Use Index”. All of the values displayed are the default values for **PSRM-QUAL**. Make no changes at this time. More information on Land Use, Land Use Indexes and Sediment Loads is provided in Section 5.0.

Review the default values for the parameters beginning with “Universal Soil Loss Factor K”. All of the values displayed are the default values for **PSRM-QUAL**. Make no changes at this time.

Click on the ***Next*** button. The following form will appear:



Subarea Data			
<b>SUBAREA #1</b>			
X coordinate of the subarea CG (-9999 to +9999) . . . . .	XCG		500
Y coordinate of the subarea CG (-9999 to +9999) . . . . .	YCG		500
Area of the subarea (acres) . . . . .	AREA		2.2
Length of characteristic flow path (feet) . . . . .	LENG		750
Slope of characteristic flow path (ft/ft) . . . . .	SLOPE		.01
Fraction of area impervious . . . . .	FRIMP		1
<b>Overland and Channel Routing</b>			
Overland flow Manning's n, impervious areas . . . . .	MN1	0.04	.1
Overland flow Manning's n, pervious areas . . . . .	MN2	0.24	.1
Overland flow sinuosity factor . . . . .	SF	1.25	.1
<b>Rainfall Losses</b>			
Curve number for impervious areas . . . . .	CN1	98	.1
Curve number for pervious areas . . . . .	CN2	70	.1
Initial abstraction factor . . . . .	IAF	0.1	.1
Depression storage, impervious areas (inches) . . . . .	DS1	0.06	.1
Depression storage, pervious areas (inches) . . . . .	DS2	0	.1
Saturated hydraulic conductivity (in/hr) . . . . .	KS	0.33	.1
Initial fraction of soil capacity wetted . . . . .	IFSW	0.2	.1
Land use index (1-4) . . . . .	LU	3	.1
Maximum sediment load (grams/curb-meter) . . . . .	MSL	380	500
Initial sediment load (grams/curb-meter) . . . . .	ISL	300	7.3
Sweeping start time (hours) . . . . .	SWST	0	.1
Sweeping time interval (days) . . . . .	SWTI	0	.1
Sweeping fraction removed . . . . .	SWFR	0	.1
Universal Soil Loss factor K . . . . .	UK	0.2	.1
Universal Soil Loss factor C . . . . .	UC	0.03	.1
Universal Soil Loss factor P . . . . .	UP	0.4	.1
Sartor-Boyd K value (1/inch) . . . . .	SBK	6	.1
Coefficient of drag . . . . .	CD	0.4	.1
Dynamic friction coefficient . . . . .	DFC	0.2	.1
Static friction coefficient . . . . .	SFC	0.4	.1
Cancel		Next -->	

X Coordinate of subarea CG (XCG) – type “500”. The specific location of the center of gravity is not critical for single subarea simulations.

Y Coordinate of subarea CG (YCG) – type “500”.

Area of subarea in acres (AREA) – type in the number of acres for this drainage area. For this example, type in 2.2. ( $1 \text{ ft}^2 = 2.296 \times 10^{-5} \text{ acres}$  or  $1 \text{ acre} = 43,560 \text{ ft}^2$ ).

Length of characteristic flow in feet (LENG) – for this example type “750”. This is the average distance traveled by the storm water before it reaches the

outfall. This value must be determined for each individual drainage area at a given facility.

Slope in ft/ft (SLOPE) – for this example type “0.01”. This represents a slope of 1.0% and is reasonable for a parking lot. Site surveys will yield the most accurate value.

Fraction impervious (FRIMP) – for this example type “1”. A value of 1 represents a completely paved, impervious drainage area.

Overland Flow Routing, Rainfall Losses, Land Use & Impervious Sediment Loading, Pervious Sediment Washoff – for this example, leave most of the values as they are, at “-1”. A value of “-1” indicates that the default value from the previous screen (and displayed to the left of the data entry box for reference) will be used in the **PSRM-QUAL** calculation.

Generally the Land Use Index and the Initial Sediment Load values must be edited here to match the use of the specific drainage area. The Land Use Index selected here is used to select the appropriate pollutant concentration factors from the data file POLC.DAT. See Section 5.0 for more information.

If you wish to use a value different from the default value in calculating this particular set of data, then replace the “-1” here with the value desired. For this example, change the Maximum Sediment Load (MSL) to 500 and the Initial Sediment Load (ISL) to 7.3. These two values will change for this particular set of data but will leave the default values of 380 and 300 unchanged.

Click on the **Next** button. The following form will appear:

DRAINAGE ELEMENT PARAMETERS	
<b>ELEMENT 1 of 1</b>	
Capacity of the drainage element (cfs) . . . . . CAP	<input type="text" value="200"/>
Pipe or channel travel time (minutes) . . . . . PT	<input type="text" value="5"/>
Muskingum X coefficient . . . . . MX	<input type="text" value="1"/>
Channel to surface velocity ratio . . . . . CTS	<input type="text" value="1"/>
Number of connecting drainage elements (3 max) . NCDE	<input type="text" value="0"/>

Capacity of drainage element (CAP) (cfs) – type “200” for this example.

Pipe travel time (PT) (minutes) – type “5” for this example.

Muskingum X coefficient – leave value at “-1”.

Channel to surface velocity ratio – leave value at “-1”.

Number of connecting drainage elements (NCDE) – type “0”.

Click on the **Next** button. The following form will appear:

Pollutant Factors for PSRM-QUAL

POLC.DAT: Pollutant Factors for PSRM-QUAL

Pollutant Concentration Factors in g/100g of TSS

	Cu	Zn	Pb	TKN	NO2+3	TP	SP	COD	BOD
Residential	0.0327	0.134	0.143	1.88	0.729	0.379	0.142	72.3	9.9
Mixed	0.0403	0.23	0.17	1.93	0.833	0.393	0.084	97	11.6
Commercial	2.99	0.328	0.151	1.71	0.829	0.291	0.116	82.6	13.5
Open/NonUrban	0.01	0.279	0.043	1.38	0.776	0.173	0.037	57.1	7.9

Pollutant Loading Factors

	curb-meters/hectare	build-up exponent
Residential	385	0.2
Mixed	385	0.2
Commercial	385	0.2
Open/NonUrban	385	0.2

Cancel
Next -->

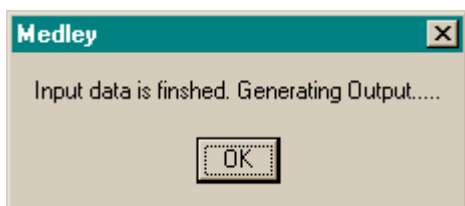
This screen displays the data in the **POLC.DAT** file. This file contains important information regarding pollutant concentration factors, specifically the Fraction of Copper ( $F_{Cu}$ ) within the total suspended solids (g Cu/100 g TSS), for the different Land Use Indexes. The  $F_{Cu}$  “loading” variable directly influences the copper concentration [Cu] associated with the runoff.

As adapted here, the “Pollutant Concentration Factors” (i.e.,  $F_{Cu}$ ) in **POLC.DAT** are all default values EXCEPT the values for copper. (The

**B.E.S.T.** model is only capable of modeling copper at the current time, so the **PSRM-QUAL** data for everything other than copper is ignored). The copper values and the corresponding Initial Sediment Loads (ISL) must be determined specifically for different land uses (i.e., industrial activities) at the facility under test. This parameter estimation technique is described more fully in Section 5.0. These values can be easily changed here; simply place the cursor in the text box and enter a new value.

For this tutorial, change the value for copper in the commercial application to 2.99. Make no other changes at this time.

Click on the **Next** button. The following form will appear:



Click the **OK** button and the Main menu will re-appear.

Repeat all the above steps, beginning with “Click on the **PSRQM** button”, for each of the eight nodes and each of the two rain events, as shown in TABLE 1 and TABLE 2 at the end of this tutorial. You will run this section of the tutorial an additional 15 times to generate the data files to select and run later in the **B.E.S.T.** model.

**NOTE:** You can alter the input file “Event.INP” for any point (such as 602\_1) by opening the file with **Notepad** and simply entering new values for selected variables. Be careful not to modify any formatting of the file and remember to save it after you are finished. This is a quick way to alter

the information without going through the above steps again. This must be done before the **Data Collection** step below.

#### 4.4 B.E.S.T.

In order to run the **B.E.S.T.** program, the appropriate output files from **PSRM-QUAL** must be selected. In addition, the timing of the rain events must be set and matched to the **PSRM-QUAL** output files.

Click on the **Data Collection** button on the main **MEDLEY** menu. The following form will appear:

**BEST datafile Options**

Base Directory

- E:\
- MEDLEY
- Tutorial**
- 602\_1
- 602\_2
- 611\_1

e:

Directory Name

Sediment File Name: E:\MEDLEY\tutorial\Bay.2tp

Curve File Name: E:\MEDLEY\tutorial\bay.2bc

Cancel

Next -->

Click on the Tutorial folder, then click on the **Next** button. The following form will appear:

**File Selection**

Left Panel:

- Drive: e:
- Folder Tree: E:\, MEDLEY, Tutorial, 602\_1
- File List: EVENT.OUT

Rain Event Information:

File Name:

Node #:

ZeroTime: 9/13/00 8:12:57 AM

Event Time: 9/13/00 8:12:57 AM

Add

---

Input File	Node	Event start(in sec. from zero time)

Remove

Next ->

The Tutorial folder should already be displayed in the file selection boxes on the left. If not, then navigate to the folder where you stored the output files from **PSRM-QUAL**. In top box, select the drive if not already selected (E: for this demo case). In the second box, navigate to, and select the **MEDLEY** folder and the **Tutorial** folder if not already selected. Highlight the first data file to be included in the **B.E.S.T.** run (602\_1 for this demo case). When you click on

602\_1, the name of the output file for that data set (EVENT.out) will appear in the third file selection box. Double click on the output file for that data set (EVENT.out). Your form should now look like the following:

**File Selection**

Drive: e:

- E:\
  - MEDLEY
    - Tutorial
      - 602\_1

**EVENT.OUT**

**Rain Event Information**

File Name: E:\MEDLEY\Tutorial\602\_1\EVENT.OUT

Node #:

ZeroTime: 9/13/00 8:12:57 AM

Event Time: 9/13/00 8:12:57 AM

Add

Input File	Node	Event start(in sec. from zero time)

Remove

Next ->

You will notice that the file name you have selected (C:\MEDLEY\Tutorial\602\_1\EVENT.OUT) appears in the **File Name** text box on the right top of the window. In addition, default zero time and event time are displayed.



In the **Node #** text box, type the number of the node that most closely approximates the location at which this drainage area will drain into the body of water. Type “602” for this demo case.

In the **Zero Time** pick list box, use the arrows to select the start date and time for the desired **B.E.S.T.** simulation. Select 2/19/00 and 12:00:01AM for this demonstration. If you are doing a one-month simulation, you might select the first day of the month, or midnight on the first day of rain, or the day before the rain starts. This zero time will be the same for all rain events in a given B.E.S.T. simulation.

In the **Event Time** pick list box select the exact date and time that the rain event in the selected file started. Select 2/19/00 and 3:00:00PM for this demonstration.

Your form should now look like the following:

e:

E:\

MEDLEY

Tutorial

602\_1

EVENT OUT

Rain Event Information

File Name

E:\MEDLEY\Tutorial\602\_1\EVENT.OUT

Node #

602

ZeroTime

2/19/00

12:01:00 AM

Event Time

2/19/00

3:00:00 PM

Add

Input File	Node	Event start(in sec. from zero time)

Remove

Next ->

Now click the **Add** button to select the file as an Input file for the **B.E.S.T.** simulation. The file name, node number and event start time (in seconds after the Zero time selected) will appear in the list box at the bottom of the window. Your form should now look like the following:

File Selection

e:

E:\

MEDLEY

Tutorial

602\_1

EVENT.OUT

Rain Event Information

File Name

Node #

602

ZeroTime

2/19/00

12:01:00 AM

Event Time

2/19/00

3:00:00 PM

Add

Input File

Node

Event start(in sec. from zero time)

E:\MEDLEY\Tutorial\602_1\EVENT.OUT	602	50340
------------------------------------	-----	-------

Remove

Next ->

Continue to select additional **PSRM-QUAL** output data files for inclusion in the simulation. By selecting all the files for the first rain event before selecting the files from the second rain event, you will only have to select the file and type in the Node #. (For example, select 611\_1 and all the other first rain event files before selecting 602\_2 and the other second rain event files). The Zero time and Event Time will default to the values for the last entry. Once all the data files for the first rain event have been selected, your form should look like the following:

File Selection

e:

E:\

MEDLEY

Tutorial

709\_1

EVENT.OUT

Rain Event Information

File Name

Node #

709

ZeroTime

2/19/00

12:01:00 AM

Event Time

2/19/00

3:00:00 PM

Add

Input File

Input File	Node	Event start(in sec. from zero time)
E:\MEDLEY\Tutorial\602_1\EVENT.OUT	602	50340
E:\MEDLEY\Tutorial\611_1\EVENT.OUT	611	50340
E:\MEDLEY\Tutorial\622_1\EVENT.OUT	622	50340
E:\MEDLEY\Tutorial\635_1\EVENT.OUT	635	50340
E:\MEDLEY\Tutorial\651_1\EVENT.OUT	651	50340
E:\MEDLEY\Tutorial\669_1\EVENT.OUT	669	50340
E:\MEDLEY\Tutorial\686_1\EVENT.OUT	686	50340
E:\MEDLEY\Tutorial\709_1\EVENT.OUT	709	50340

Remove

Next ->

Continue again to select additional **PSRM-QUAL** output data files for inclusion in the simulation until all the files for all the rain events have been selected and their start times entered. Select 2/23/00 and 6:00:00PM for the start time of the second rain event in this demonstration. When all the data files for this demonstration have been selected, your form should look like the following:

File Selection

e:

E:\

MEDLEY

Tutorial

709\_2

EVENT.OUT

Rain Event Information

File Name

Node #

709

ZeroTime

2/19/00

12:01:00 AM

Event Time

2/23/00

6:00:00 PM

Add

Input File

Node

Event start(in sec. from zero time)

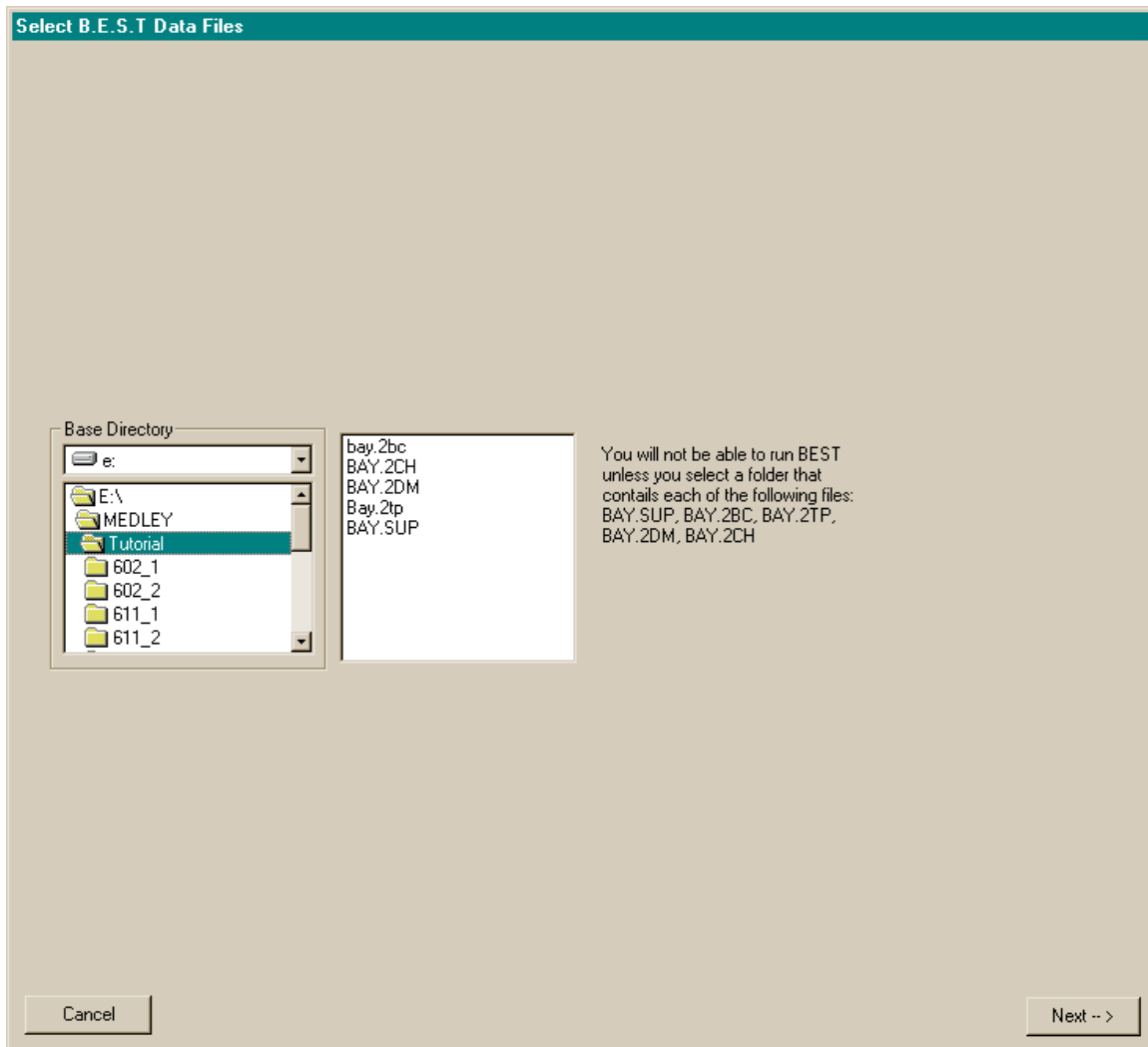
E:\MEDLEY\tutorial\602_2\EVENT.OUT	602	406740
E:\MEDLEY\tutorial\611_1\EVENT.OUT	611	50340
E:\MEDLEY\tutorial\611_2\EVENT.OUT	611	406740
E:\MEDLEY\tutorial\622_1\EVENT.OUT	622	50340
E:\MEDLEY\tutorial\622_2\EVENT.OUT	622	406740
E:\MEDLEY\tutorial\635_1\EVENT.OUT	635	50340
E:\MEDLEY\tutorial\635_2\EVENT.OUT	635	406740
E:\MEDLEY\tutorial\651_1\EVENT.OUT	651	50340
E:\MEDLEY\tutorial\651_2\EVENT.OUT	651	406740
E:\MEDLEY\tutorial\669_1\EVENT.OUT	669	50340
E:\MEDLEY\tutorial\669_2\EVENT.OUT	669	406740
E:\MEDLEY\tutorial\686_1\EVENT.OUT	686	50340
E:\MEDLEY\tutorial\686_2\EVENT.OUT	686	406740
E:\MEDLEY\tutorial\709_1\EVENT.OUT	709	50340
E:\MEDLEY\tutorial\709_2\EVENT.OUT	709	406740

Remove

Next ->

When you have selected all the appropriate files for the **B.E.S.T.** calculations, click on the **Next** button. You will be taken back to the Main Menu.

When you are ready to begin the **B.E.S.T.** calculation module, click on the **Run B.E.S.T.** button. The following form will appear:



Navigate to and select the folder where the data files you just selected are stored. Select "E:/MEDLEY/Tutorial" for the case of this tutorial. The five required files should be present in the box to the right. Then click the **Next** button.

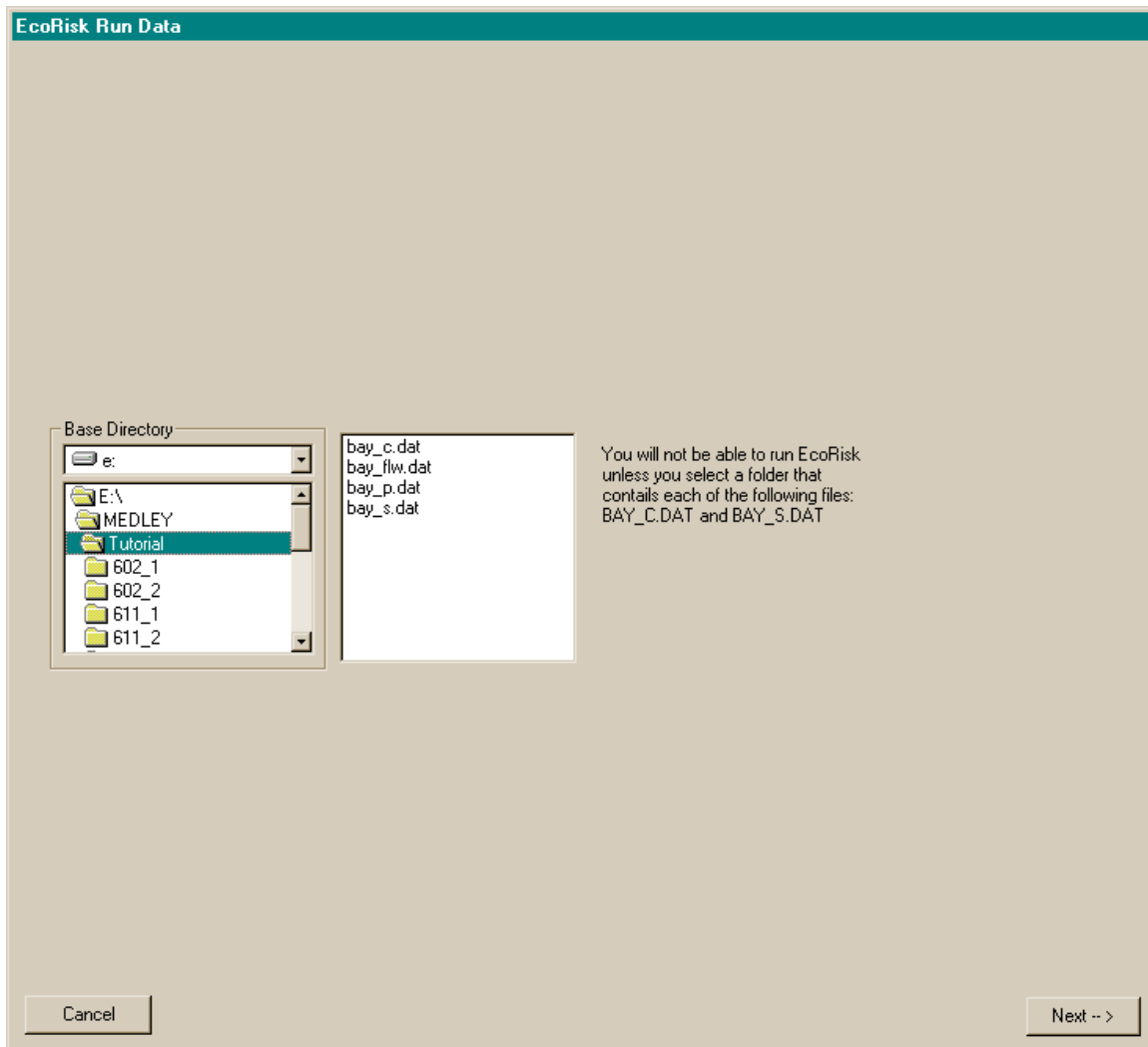
An application button will appear at the bottom of your screen that says "Running **B.E.S.T.**" This program will run in the background on your computer, allowing you to perform other tasks (such as getting your e-mail or typing a document) while it runs. Depending on how many data points you have entered and the time period covered, and what other software you have running and how much

you are actively using the computer, the calculations will take several days to run. **Do not turn your computer off overnight**; continue to let the program run. On computers with a 600MHZ Pentium III, 256MB 100MHZ RAM, 20GB type EIDE disk, L2 CACHE 512KB, an 8-node, three rain-event simulation covering a time period of one month, required about 60 hours to complete the calculations.

As long as the “Running **B.E.S.T.**” button appears at the bottom of your screen, **B.E.S.T.** is still running. When the calculations are complete, a message will appear on your screen saying that they are complete, and the main **MEDLEY** menu will again appear.

#### **4.5 ECORISK**

From the main **MEDLEY** menu, double click on the ***Run ECORISK*** button. The following form will appear:



Navigate to the Base Directory file selection box and click on the folder where your **B.E.S.T.** simulation data is stored (E:\MEDLEY\Tutorial in this case). The four required files (generated in the **Data Collection** step above) should be displayed in the window on the right. Click on the **Next** button. The following form will appear:



Untitled - EcoRisk

File View Compute Species Help

\* No name

Name: No name

Habitat

☒ Water
 ☐ Sediment
 ☐ Used

Location

☒ All area

Xmin: 0 Xmax: 0  
 Ymin: 0 Ymax: 0

Copper Risk Criteria

Acute LC50 (mg/L) 0  
 Chronic LC50 (mg/L) 0

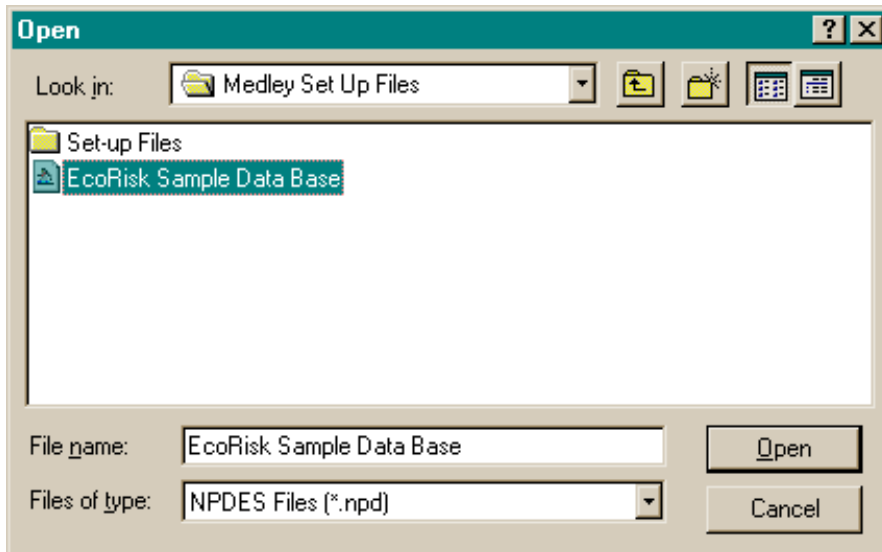
OK Undo

Ready NUM

This form contains two windows. The left window contains a list of species in the database. The right window contains information on the species' location within the bay and copper risk criteria. By clicking on and highlighting a species in the left window, the locations and parameters associated with that species appear in the right window.

The form shown above is the default form. At this point, either a new data set must be created or an existing data set must be loaded. To build a new data set, see Section 4.5.1. To load an existing data set, select **Open** from the **File** menu, then navigate to the desired file, highlight and click on the **Open** button.

A sample data set has been included with the **MEDLEY** software. For the purpose of this tutorial, navigate to the folder **Medley Set Up Files**, then select the file **EcoRisk Sample Data Base**.



Click on the **Open** button and the following form will appear.

**EcoRisk Sample Data Base - EcoRisk**

File View Compute Species Help

- ♦ *Pleurobrachia pileus* - sea gooseberry
- ♦ *Neanthes arenacedentata* - worm
- ♦ *Crassostrea gigas* - Pacific oyster
- ♦ *Carcinus maenas* - Euro. shore crab
- ♦ *Mysidopsis bahia* - mysis shrimp
- ♦ *Echinometra mathaei* - sea urchin
- ♦ *Leiostomus xanthurus* - spot fish
- ♦ *Paralichthys dentatus* - flounder
- ♦ *Homarus americanus* - lobster
- ♦ *Nereus diversicolor* - clam worm
- ♦ *Artemia salina* - brine shrimp
- ♦ *Daphnia magna* - water flea
- ♦ *Balanus eburneus* - barnacle
- ♦ ***Cragnon cragnon* - shrimp**

Name:

Habitat  
☒ Water ☐ Sediment ☒ Used

Location  
☐ All area  
Xmin:  Xmax:   
Ymin:  Ymax:

Copper Risk Criteria  
Acute LC50 (mg/L)   
Chronic LC50 (mg/L)

Ready

This sample data set has been compiled using acute and chronic LC50 data found in the literature. A unique data set that is appropriate for a given geographic location should be developed for use at each facility. This data set should be developed in a cooperative effort with the local regulating agency using species and LC50 data that are specific to the local environment and of interest to local regulators.

#### 4.5.1 Adding and Deleting Organisms



Click on the **Fish** icon on the toolbar or select **New Species** from the **Species** menu to add a new species.

Type the name of the species in the **Name** text box.

Click on either the **Water** or the **Sediment** radial button to select the normal or major habitat for the species.

Click on the **Used** check box to indicate whether you want this species included in the risk calculation. One, a few, or all species may be included in each risk calculation that is done. Any species may be included or excluded by checking or un-checking this box.

Click on the **Whole Bay** check box if the species lives throughout the water body, or deselect the check mark in the **Whole Bay** check box and enter x and y coordinates to select a specific portion of the water body. See the San Diego Bay grid, Figure 3, at the end of this section to identify approximate x and y coordinates, or use GMS FEMWATER as described in Appendix E.

Enter the **Acute LC50** and the **Chronic LC50** parameters for the species. These should be EC50 data in mg/liter for the specific species when exposed to copper, and may be found in the literature or from your local regulator.

When all the information is entered, click on the **Okay** button. The species and its data will be entered.



To delete a species, click on and highlight the species, then click on the **No Fish** icon, or select **Remove Species** from the **Species** menu.

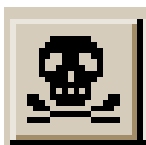
The species will be deleted.

To save a new data set, select **Save As** from the **File** menu, name the file and click **Okay**. To save an updated or revised data set, select **Save** from the **File** menu.

#### 4.5.2 Risk Calculation

Select the species (one or more) that are to be included in the risk calculation in the left hand window. Click on the large green diamond to left of species name to deselect, or click on the small black diamond to select. This is an alternative method (to the **Used** box) to select or deselect species to be included in the risk calculation.

If desired, update any information in the right hand window for any of the species selected.



With the desired test species selected, click on the **Skull and Crossbones** icon, or select **Toxicity** from the **Compute** menu.

The following form will appear:

The 'Compute Toxicity' dialog box has a title bar with a close button. It contains two main sections: 'Toxicity Function' and 'Options'. In the 'Toxicity Function' section, the 'Acute' radio button is selected and highlighted with a dashed border, while the 'Chronic' radio button is unselected. In the 'Options' section, four radio buttons are listed: 'Full model' (unselected), 'Time average' (unselected), 'Space average' (unselected), and 'Overall average' (selected). To the right of these options are two buttons: 'OK' and 'Cancel'.

With the **Acute** radial button highlighted, the risk calculation will be based on the Acute LC50 entered for the species. To select a calculation based on the Chronic LC50, click on the **Chronic** radial button. The following form will appear.

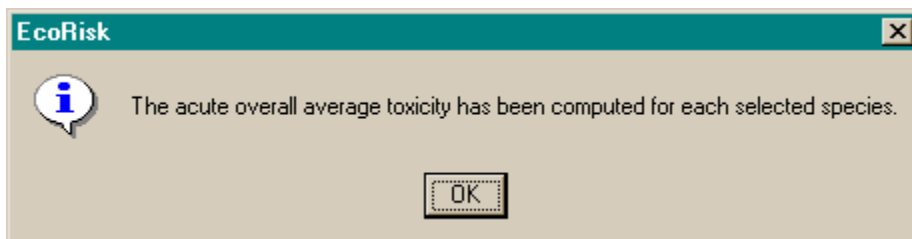
This is the same 'Compute Toxicity' dialog box, but now the 'Chronic' radio button in the 'Toxicity Function' section is selected and highlighted with a dashed border. The 'Acute' radio button is unselected. The 'Options' section remains the same, with 'Overall average' selected. The 'OK' and 'Cancel' buttons are still present on the right.

The acute and chronic forms allow the choice of the type of data averaging calculation to be done, and whether a Chronic or Acute risk estimate is desired. See Section 5.3 for more information on specifically how the risk estimate is calculated in each of these cases.

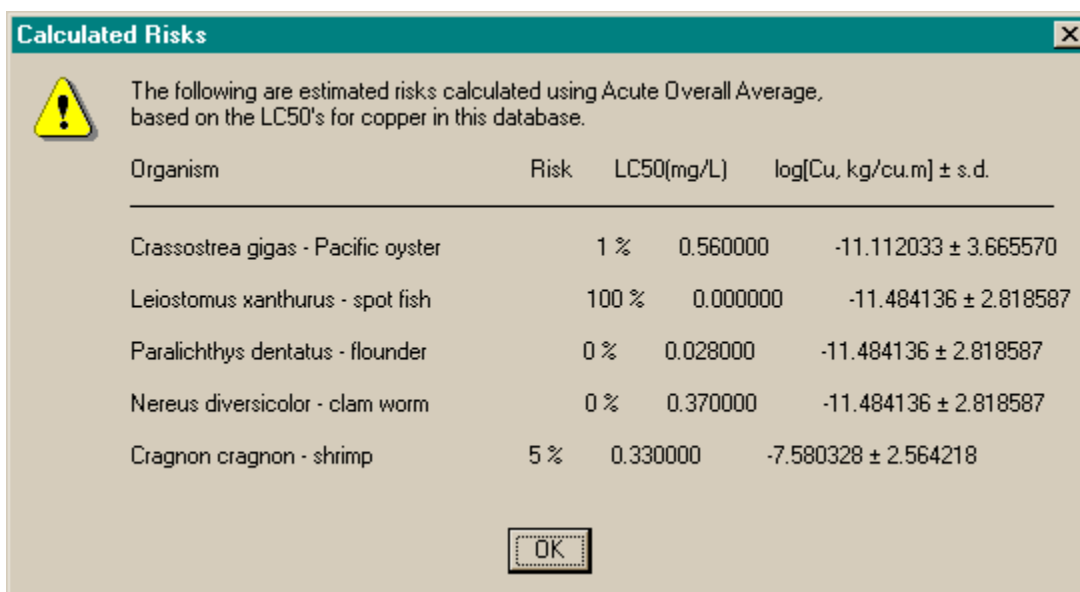
<b>Acute:</b>	The risk calculation is performed by comparing the Acute LC50 in the database for each species selected to the copper concentrations generated by the <b>B.E.S.T.</b> simulation.
<b>Chronic:</b>	The risk calculation is performed by comparing the Chronic LC50 in the database for each species selected to the copper concentrations generated by the <b>B.E.S.T.</b> simulation.
<b>Time Average:</b>	Calculates the species' risk of exposure to levels of copper above the specified LC50 in the database over the time frame of the <b>B.E.S.T.</b> simulation. This method uses the probability distribution of copper concentrations when averaged over time for each bay location.
<b>Space Average:</b>	Gives the species' risk of exposure to levels of copper above the specified LC50 in the database over the geographical area of the <b>B.E.S.T.</b> simulation. This method uses the probability distribution of copper concentrations when averaged over all bay locations for each time interval. This option is not available for Chronic calculations since the concept of a Chronic exposure at one distinct time interval is inappropriate.
<b>Overall Average:</b>	Gives the organism's risk of exposure to levels of copper above the specified LC50 in the database over the time frame and geographical location of the <b>B.E.S.T.</b> simulation. This method uses the probability distribution of copper concentrations when averaged over all times and for all bay locations.
<b>Full Model:</b>	This option is not currently active. It is reserved for future upgrades.

Choose either the **Acute** or the **Chronic** radial button, then choose the type of averaging to be done. Click the **Okay** button.

After a short time period (up to a few minutes), the following form will appear:



Click the **Okay** button. The following form will appear with the calculated risk results for all the selected species.





The form indicates whether Acute or Chronic LC50s were used in the estimation, and what type of averaging was selected. The table displayed in the form lists the species selected, the calculated risk, the LC50 that is stored in the data base, and the copper concentration statistics for the species' selected habitat (water or sediment, and whole bay or specific x,y locations). The risk result represents the % risk or the % chance that the selected organism would be exposed to a copper concentration greater than its LC50 in its habitat as a result of the copper dispersion modeled by **PSRM-QUAL** and **B.E.S.T.**

**NOTE:** If no value for LC50 was entered into the database for a given species, the default value in the database is zero. Therefore, the risk calculation will assume an LC50 of zero, and in most cases, the estimated risk will be 100%. This is the case in the form above for *Leiostomus xanthurus* – *spot fish*. This should be taken into consideration when interpreting results, since many species do not have published LC50 data for both acute and chronic exposures.

**NOTE:** If desired, Risk Criteria other than LC50 may be entered into the database. For example, criteria such as EC50 may be more applicable for a given situation. The calculations would be performed in the same way, except that the risk estimate would be performed by comparison to the entered criteria. If this option is elected, it should be documented and considered appropriately when interpreting results.

**NOTE:** When analyzing this data, it is important to remember that the average concentrations that are used for these calculations are averages that may include many points equal to essentially zero. If the **B.E.S.T.** program was run including long periods of time when there were no rain events, then a large number of “zero” concentrations have been averaged into the data set. In addition, if the whole bay is included in the average

(by designating that the species lives in the whole bay) it is also likely that a large number of “zero” concentrations are included in the average.

If you note in the calculated result above, the average of the log of the concentration for *Cragnon cragnon* – *shrimp* is significantly different from the average listed for the other species. This is because in the database, the location for the *Cragnon cragnon* – *shrimp* has been limited to an area immediately adjacent to the shipyard nodes (see the **EcoRisk Sample Data Base** window displayed on page 35). This means that there are fewer “zeros” included in the average, and the resulting average concentration is higher.

To exit the application, select **Exit** from the **File** menu. The main **MEDLEY** menu will appear. Click on the **Exit** button, and the application will close.

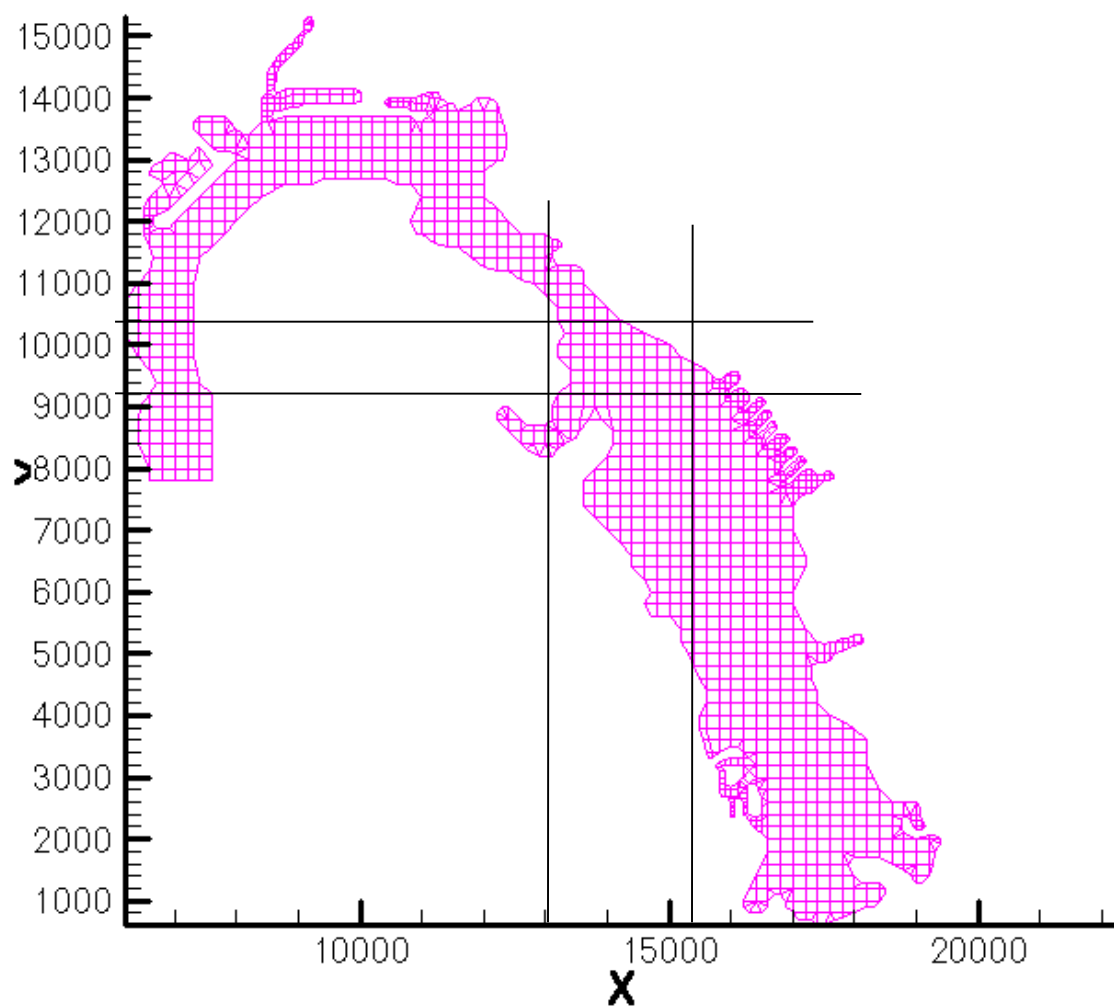


Figure 3. Grid with X and Y coordinates for San Diego Bay.

## 5.0 DETAILS ON DATA FOR MODEL INPUT

### 5.1 PSRM-QUAL

#### 5.1.1 Initial Sediment Load and $F_{Cu}$

The activities that take place on a given drainage area (Land Use) and their associated sediment and pollutant (copper) levels are key parameters in the **PSRM-QUAL** prediction of pollutant discharge into a body of water. Thus the particular facility and the activities that occur within each drainage area need to be reviewed and assessed before any modeling is done. Once each drainage area is defined and the major activities that take place within the area are determined, the stormwater that is generated by each drainage area needs to be tested to determine both sediment levels and copper concentrations. Data to determine the total solids (Initial Sediment Load, ISL) that would be washed from a drainage area by a rain event must be determined, in the units of grams/curb-meter. Similarly, data on typical copper concentrations ( $F_{Cu}$ ) in the stormwater from a drainage area by a rain event must be determined, in the units of grams/100 grams of TSS (g Cu/100 g TSS). These data will provide important information regarding pollutant concentration factors, specifically the Fraction of Copper ( $F_{Cu}$ ) within the suspended solids (g Cu/100 g TSS), for each different drainage area. The  $F_{Cu}$  “loading” variable directly influences the [Cu] associated with the runoff.

The ISL and  $F_{Cu}$  values will vary depending on the amount of work that has been performed in the area, how long it has been since the last rain event, how hard it rains and for how long (to some degree), and what BMPs are used. Because of this, it is best to collect data from several rain events to get a good average or “typical” value. Alternatively, a worst-case value could be used to predict the “worst case”.

In order to determine representative ISL and  $F_{Cu}$  values for the NASSCO demonstration, storm water grab samples were collected from a number of NASSCO outfalls shortly after many rain events. These results represent a single point on an outfall's pollutograph, and were therefore "back-calculated" to obtain representative sediment (i.e., ISL) and contaminant loads (i.e.,  $F_{Cu}$ ). Storm event characteristics were obtained by purchasing 15-minute rain gage data for a rain gage maintained by NOAA at Lindbergh Field, San Diego, CA. Estimates of ISL and  $F_{Cu}$  were made from five rain events and five outfalls and are shown in Table 1.

### 5.1.2 Land Use Indexes

**PSRM-QUAL** allows for four types of land use, with each area expected to have different levels of sediment and different levels of pollutants. In the **PSRM-QUAL** program as originally written, these areas are called Residential, Mixed, Commercial, and Open/Non-Urban. These names will appear on the POLC.DAT form when running this model; the names cannot be changed in the model. However, in order to use this **PSRM-QUAL** model for shipyards and other similar facilities, the four types of land use can be re-defined as areas specific to the facility of interest, and sediment and pollutant quantities characteristic of those areas can be assigned using the POLC.DAT form. Thus Land Use Index 1, which is called Residential in **PSRM-QUAL**, can be considered as Material Storage Area for use by a shipyard, with the corresponding data modified in POLC.DAT.

An analysis of NASSCO drainage areas, shipyard activities and the sediment and copper loading test results suggested three "levels" of contamination and are summarized in Table 1. Stormwater test results from two of the outfalls were relatively similar and were therefore grouped under the Land Use Index name of "Material Storage Areas." Stormwater test results from two more outfalls were

also relatively similar and were grouped under the Land Use Index name of “Machine/Electrical Shops.” Stormwater test results from the last outfall tested had the highest levels of contaminants and its Land Use Index name is “Maintenance Areas.” **PSRM-QUAL** can define four Land Use Indexes, so the fourth Land Use category has been reserved for “Diversion Systems.” No sampling data was available to estimated ISL and  $F_{Cu}$  for these discharges.

The four Land Use Indexes defined for the NASSCO shipyard and their associated ISL and  $F_{Cu}$  values are presented in Table 1. A similar Table should be generated for each individual facility before using this model.

Table 1. Estimated loading values for different Land Use Indexes at NASSCO.

	<b>Material Storage Areas</b>	<b>Machine/ Electrical Shops</b>	<b>Maintenance Areas</b>	<b>Diversion Systems</b>
<b>PSRM-QUAL Land Use Index</b>	1	2	3	4
<b>ISL (mean±sd) (g/curb-meter)</b>	10.7±6.4	41.4±30.8	353±391	NA
<b>ISL (low - high) (g/curb-meter)</b>	5 - 20	5 - 90	55 - 820	NA
<b><math>F_{Cu}</math> (mean±sd) (g/100 g TSS)</b>	2.56±2.68	3.42±3.36	1.72±1.59	NA
<b><math>F_{Cu}</math> (low- high) (g/100 g TSS)</b>	0.1 - 7.4	0.4 - 9.5	0.4 - 3.6	NA

## 5.2 B.E.S.T.

As supplied, this NPDES application software has been set up to model copper discharges from the NASSCO shipyard locations into San Diego Bay. In order to model pollutant discharges other than copper, or to model discharges into bodies of water other than San Diego Bay, the software will have to be modified or re-programmed by a person skilled at doing computer programming. Source code has been provided to allow this, and further information is provided in Appendices E and F to the NPDES report.

Discharges from other locations within San Diego Bay may be modeled without programming changes by following the procedures described below.

### 5.2.1 Alternate San Diego Bay Locations

NASSCO node locations in the bay are 602, 611, 622, 635, 651, 669, 686, and 709 as used throughout this tutorial. In order to run the **B.E.S.T.** model and simulation for other locations in San Diego Bay, it is necessary to select different nodes within the bay grid. The nodes for any given location on San Diego Bay may be found using **GMS FEMWATER** as described in Appendix E to the NPDES report.

Once the new nodes have been determined, **PSRM-QUAL** should be run just as described in the tutorial, although file names may be changed to correspond to the nodes of interest. When using the **Data Collection** option from the main **MEDLEY** menu to select files for inclusion in the **B.E.S.T.** calculations (Section 4.4), the nodes for the location of interest should be entered instead of the nodes for NASSCO shipyard given in the tutorial. Then, after the **Data Collection** step is complete, two files need to be edited before running **B.E.S.T.** These two files are **bay.2bc** and **bay.2tp**.

**Editing bay.2bc** - Navigate to the folder where your data files are stored (E:\MEDLEY\Tutorial as used in this tutorial). Double click on the file named **bay.2bc** and open the file with an appropriate word processing application, such as **NOTEPAD**. The file is several pages long, and the first page will be similar to that shown in Figure 4 at the end of this tutorial.

About halfway down the page, there are three columns of information that begin with “SS1”. The second column of numbers following SS1 lists the node numbers; the third column lists the associated curve numbers. Edit the node numbers to those for the locations where the discharges will enter the bay. Delete lines beginning with “SS1” if fewer than 8 nodes are required. Be careful not to modify any line spacing or any other lines at this time. An example of a properly edited file is given in Figure 5 at the end of this tutorial.

Save and close the file.

**Editing bay.2tp** - Navigate to the folder where your data files are stored (E:\MEDLEY\Tutorial as used in this tutorial). Double click on the file named **bay.2tp** and open the file with an appropriate word processing application, such as **NOTEPAD**. The file is several pages long, and the first page will be similar to that shown in Figure 6 at the end of this tutorial.

About halfway down the page, there are three 8-line sections of information that begin with “SS1”, “SS2”, and “SS3”. The second column of numbers following each SS number lists the node numbers; the last column in each section lists the associated data set numbers (1-24). Edit the node numbers to those for the locations where the discharges will enter the bay. Delete the appropriate lines beginning with “SS1”, “SS2”, and “SS3” if fewer than 8 nodes are required, and then renumber the data set numbers. Be careful not to modify any line spacing or any other lines at this time. An example of a properly edited file is given in Figure 7 at the end of this tutorial.



Save and close the file. Proceed with running **B.E.S.T.** as described in Section 4.4.

### 5.3 ECORISK

The **ECORISK** software calculates two main pieces of information: the average copper concentration (and standard deviations) in the environment/ bay which was modeled and to which an organism is exposed, and the risk of exposure of an organism to copper concentrations above its LC50 for copper. The copper concentration can be further broken down into **Space Averages**, **Time Averages**, and **Overall Averages**.

#### Concentration Statistics

**Space Average** – For the space average, the copper concentrations in the input file are averaged over all points listed for a certain time. As an example, consider the following sample data set.

Time Period	X value of point	Y value of point	Concentrations
0.0 minutes	0	0	2
	1	1	3
	2	1	1
30.0 minutes	0	0	4
	1	1	7
	2	1	3

The space average is determined by the following calculations.

The logs of all the concentration values for the first time interval are averaged:

$$\text{Avg (0.0)} = \frac{\log(2) + \log(3) + \log(1)}{3} = .2593$$

The logs of all the concentration values for the next time interval are averaged:

$$\text{Avg (30.0)} = \frac{\log(4) + \log(7) + \log(3)}{3} = .6414$$

Calculations continue in this manner until all concentration averages have been calculated.

**Time Average** – For the time average, the copper concentrations in the input file are averaged for each x,y location over all time periods. Using the sample data set as listed in the above discussion, the time average is determined by the following calculations.

The average of point (0,0) is determined by averaging the logs of the concentrations for that point for all times:

$$\text{Avg (0,0)} = \frac{\log(2) + \log(4)}{2} = .4515$$

The average of point (1,1) is determined by averaging the logs of the concentrations for that point for all times:

$$\text{Avg (1,1)} = \frac{\log(3) + \log(7)}{2} = .6611$$

The average of point (2,1) is determined by averaging the logs of the concentrations for that point for all times:

$$\text{Avg (2,1)} = \frac{\log(1) + \log(3)}{2} = .2386$$

Calculations continue in this manner until the time averaged concentration for all points have been calculated.

**Overall Average** – The overall average is found by averaging the logs of the concentrations for all x,y locations and for all time periods listed in the input file. Again using the above sample data set, the overall average is determined by the following calculation.

$$\text{Avg (overall)} = \frac{\log(2) + \log(3) + \log(1) + \log(4) + \log(7) + \log(3)}{6} = .4504$$

## **Risk**

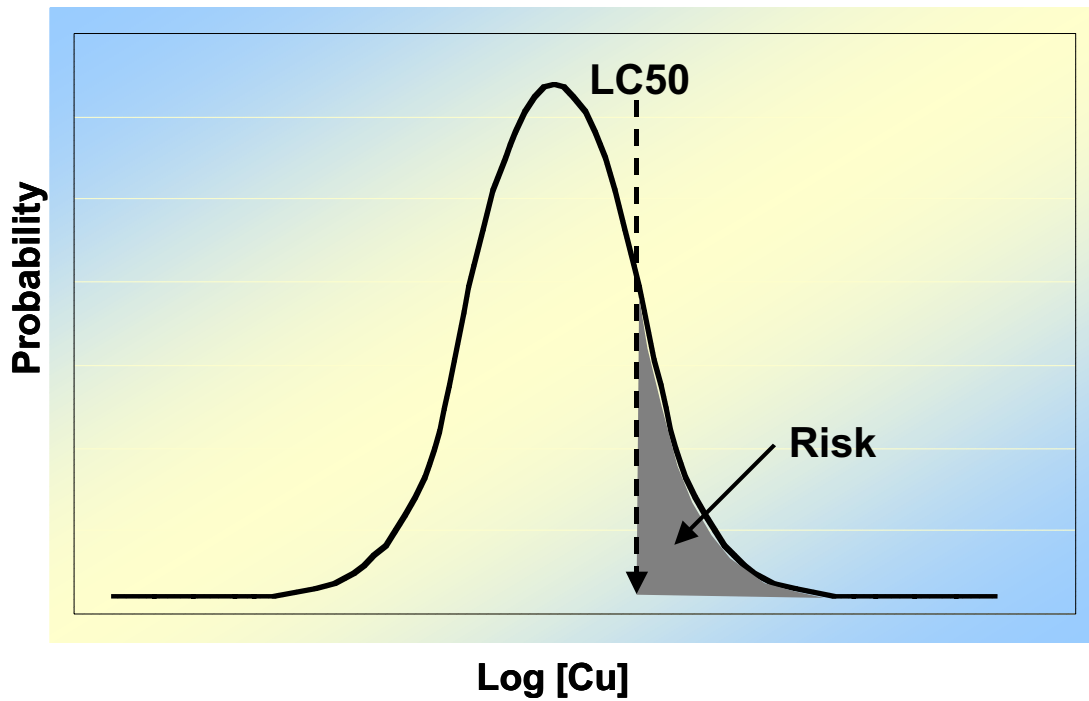
Risk is found by performing a statistical calculation on the concentration averages and standard deviations found during the **Concentration Statistics** calculations described above. The risk is mathematically defined as the area under a section of the curve provided by the following equation:

$$F(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

Where the  $\sigma$  is the standard deviation and can be defined as:

$$\sigma(x_1 \dots x_N) = \sqrt{\frac{1}{N-1} \sum (x_j - \mu)^2}$$

And  $\mu$  is the mean of samples  $x_1$  through  $x_N$ .



The integration of the function uses the trapezoidal method algorithm. This method approximates a true integration in the manner used in this program. The

acute and chronic copper risk criteria (LC50) entered in the database for each organism determine the lower bound of the integration. Because the function curve describes the range of copper concentrations to which the organism may be exposed over time and space, integrating from this lower bound (LC50) concentration to a point beyond the end of the curve (infinity) gives the risk of exposure of the organism to copper concentrations which exceed the respective LC50s.

**TABLE 1**  
**Data for Rain Event #1**

**Zero Time:** 2/19/2000, 12:01:00AM

**Rain Event #1 Time:** 2/19/2000, 3:00:00PM

Parameter	File Name	602_1	611_1	622_1	635_1	651_1	669_1	686_1	709_1
Time Parameters	HYDTI	10	10	10	10	10	10	10	10
	HYDNPT	16	16	16	16	16	16	16	16
Rainfall Parameters	RFNPT	6	6	6	6	6	6	6	6
	Rainfall Pt #1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Rainfall Pt #2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Rainfall Pt #3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	Rainfall Pt #4	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Rainfall Pt #5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Rainfall Pt #6	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Subarea Data	AREA	2.2	4.2	2.6	9	2.1	4.3	2.4	16.6
	LENGTH	750	400	250	400	400	400	350	550
	SLOPE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	FRIMP	1	1	1	1	1	1	1	1
	MSL	500	500	500	500	500	500	500	500
	ISL	7.3	13.4	42.2	42.2	42.2	42.2	40.6	13.4
Pollutant Factors	Cu, Commercial	2.99	2.12	4.46	2.37	4.46	4.46	4.46	2.12

**TABLE 2**  
**Data for Rain Event #2**

**Zero Time:** 2/19/2000, 12:01:00AM

**Rain Event #1 Time:** 2/23/2000, 6:00:00PM

Parameter	File Name	602_2	611_2	622_2	635_2	651_2	669_2	686_2	709_2
Time Parameters	HYDTI	15	15	15	15	15	15	15	15
	HYDNPT	30	30	30	30	30	30	30	30
Rainfall Parameters	RFNPT	8	8	8	8	8	8	8	8
	Rainfall Pt #1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Rainfall Pt #2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Rainfall Pt #3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Rainfall Pt #4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Rainfall Pt #5	0	0	0	0	0	0	0	0
	Rainfall Pt #6	0	0	0	0	0	0	0	0
	Rainfall Pt #7	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	Rainfall Pt #8	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Subarea Data	AREA	2.2	4.2	2.6	9	2.1	4.3	2.4	16.6
	LENGTH	750	400	250	400	400	400	350	550
	SLOPE	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	FRIMP	1	1	1	1	1	1	1	1
	MSL	500	500	500	500	500	500	500	500
	ISL	7.3	13.4	42.2	42.2	42.2	42.2	40.6	13.4
Pollutant Factors	Cu, Commercial	2.99	2.12	4.46	2.37	4.46	4.46	4.46	2.12

**Figure 4**  
**Sample Bay.2bc File Before Editing Nodes**

```

                                bay
WMS2D2BC
T1
T2
T3      SanDiego_200 (BAY ONLY)
OP1  12   1      KMOD IRUN
OP2  1   3   12   0   1  -3   1  ILUMP IPNTS IQUAR IDIFF IALLOW IMODEL
IQUASI
OP3  0.5  0.5  1.0      W OME OMI
OP4  1   1.0      IEIGEN GG
OP5  -1   0.0  0.0      ISK  ANGLE1 ANGLE2
IP1  6   200 1.0e-4 1.0e-3 1.0e-4 0.0001 0.001  NNITER NPITER TOLBH TOLB
V V_CUT FMSR ACCU
PT1  1   1      NXW IDETQ
MP1  1  0.01  0.0  0.0  0.0  NMAT N E-XX E-YY E-XY
MP2  1   1  1000.0      ITUNIT ILUNIT RHO
TC1  2592000.000 43200.00 60  4320 60 360 12      TMAX DELT
OC1  0 2160      JOPT KPRT
OC2  2   1   2   0      NSELT KPRO(1) KPRO(2)
      KPRO(3)
OC3  0   0  1080      IFILE
KOPT KDSK
OC4  2   1   2   0      KSELT KSAVE(1) KSAVE(2)
KSAVE(3)
OB1   1   1  -1
OB1   2   1  -1
OB1   3   1  -1
OB1   4   1  -1
OB1   5   1  -1
OB1   6   1  -1
SS1  602   2
SS1  611   3
SS1  622   4
SS1  635   5
SS1  651   6
SS1  669   7
SS1  686   8
SS1  709   9
ICH  0  0.0d0
ICU  0  0.0e0  0.0e0
ICS  0
XY1   1   2  0  0  0  0
-1.0   1.200
-1.0  .00000E+00
XY1  2 90 0 0 0 0 Curve no. 2 with 90 points to be applied to node 602
0  0.00000
50940  0.00000
50940.01  0.00566
51540  0.00566
51540.01  0.03115
52140  0.03115
52140.01  0.05663

```



**Figure 5**  
**Sample Bay.2bc File After Editing Nodes**

```

                                bay
WMS2D2BC
T1
T2
T3      SanDiego_200 (BAY ONLY)
OP1  12   1                      KMOD IRUN
OP2  1   3   12   0   1  -3   1  ILUMP IPNTS IQUAR IDIFF IALLOW IMODEL
IQUASI
OP3  0.5   0.5   1.0                W OME OMI
OP4  1     1.0                IEIGEN GG
OP5  -1     0.0   0.0                ISK ANGLE1 ANGLE2
IP1  6   200 1.0e-4 1.0e-3 1.0e-4 0.0001 0.001 NNITER NPITER TOLBH TOLB
V V_CUT FMSR ACCU
PT1  1   1                      NXW IDETO
MP1  1  0.01  0.0  0.0  0.0  0.0 NMAT N E-XX E-YY E-XY
MP2  1   1  1000.0                ITUNIT ILUNIT RHO
TC1  2592000.000 43200.00 60  4320 60 360 12                TMAX DELT
OC1  0 2160                                JOPT KPRT
OC2  2   1   2   0                NSELT KPRO(1) KPRO(2)
      KPRO(3)
OC3  0   0  1080                                IFILE
      KOPT KDSK
OC4  2   1   2   0                KSELT KSAVE(1) KSAVE(2)
      KSAVE(3)
OB1   1     1  -1
OB1   2     1  -1
OB1   3     1  -1
OB1   4     1  -1
OB1   5     1  -1
OB1   6     1  -1
SS1  511     2
SS1  522     3
SS1  535     4
SS1  551     5
SS1  569     6
ICH  0   0.0d0
ICU  0   0.0e0  0.0e0
ICS  0
XY1   1   2  0  0  0  0
-1.0     1.200
-1.0     .0000E+00
XY1 2 90 0 0 0 0 Curve no. 2 with 90 points to be applied to node 511
0  0.00000
22140  0.00000
22140.01  0.01982
22740  0.01982
22740.01  0.11044
23340  0.11044
23340.01  0.14158
23940  0.14158
23940.01  0.10194
24540  0.10194

```

**Figure 6**  
**Sample Bay.2tp File Before Editing Nodes**

```

Bay
WMS2D2TP
T1
T2
T3
OP1 1 1 IDCHEM IDSED
OP2 1 1 11 1 ILUMPT IPNTST IQUART IADAPT
OP3 0.5 0.5 1.0 WT OMET OMIT
OP4 1 1.0 IEIGENT GGT
IP1 50 200 1.0e-4 1.0e-4 NNITERT NPITERT TOLBC TOLBS
PT1 1 1 NXWT IDETQT
MP1 1 0.0d0 0.0d0 5.2d0 NMAT L-DISP T-DISP DIFF
SS1 602 1 1
SS1 611 1 2
SS1 622 1 3
SS1 635 1 4
SS1 651 1 5
SS1 669 1 6
SS1 686 1 7
SS1 709 1 8
SS2 602 1 1 9
SS2 611 1 1 10
SS2 622 1 1 11
SS2 635 1 1 12
SS2 651 1 1 13
SS2 669 1 1 14
SS2 686 1 1 15
SS2 709 1 1 16
SS3 602 1 1 1 17
SS3 611 1 1 1 18
SS3 622 1 1 1 19
SS3 635 1 1 1 20
SS3 651 1 1 1 21
SS3 669 1 1 1 22
SS3 686 1 1 1 23
SS3 709 1 1 1 24
ON1 1 0.1D0
ON2 1 1 2 1 1
ON2 2 2 3 1 1
ON2 3 3 4 1 1
ON2 4 4 5 1 1
ON2 5 5 6 1 1
ON3 1 1 2 1 1 1
ON3 2 2 3 1 1 1
ON3 3 3 4 1 1 1
ON3 4 4 5 1 1 1
ON3 5 5 6 1 1 1
ON4 1 1 2 1 1 1 1 1
ON4 2 2 3 1 1 1 1 1
ON4 3 3 4 1 1 1 1 1
ON4 4 4 5 1 1 1 1 1
ON4 5 5 6 1 1 1 1 1

```

**Figure 7**  
**Sample Bay.2tp File After Editing Nodes**

```

WMS2D2TP
T1
T2
T3
OP1 1 1 IDCHEM IDSED
OP2 1 1 11 1 ILUMPT IPNTST IQUART IADAPT
OP3 0.5 0.5 1.0 WT OMET OMIT
OP4 1 1.0 IEIGENT GGT
IP1 50 200 1.0e-4 1.0e-4 NNITERT NPITERT TOLBC TOLBS
PT1 1 1 NXWT IDETQT
MP1 1 0.0d0 0.0d0 5.2d0 NMAT L-DISP T-DISP DIFF
SS1 511 1 1
SS1 522 1 2
SS1 535 1 3
SS1 551 1 4
SS1 569 1 5
SS2 511 1 1 6
SS2 522 1 1 7
SS2 535 1 1 8
SS2 551 1 1 9
SS2 569 1 1 10
SS3 511 1 1 1 11
SS3 522 1 1 1 12
SS3 535 1 1 1 13
SS3 551 1 1 1 14
SS3 569 1 1 1 15
ON1 1 0.1D0
ON2 1 1 2 1 1
ON2 2 2 3 1 1
ON2 3 3 4 1 1
ON2 4 4 5 1 1
ON2 5 5 6 1 1
ON3 1 1 2 1 1 1
ON3 2 2 3 1 1 1
ON3 3 3 4 1 1 1
ON3 4 4 5 1 1 1
ON3 5 5 6 1 1 1
ON4 1 1 2 1 1 1 1 1
ON4 2 2 3 1 1 1 1 1
ON4 3 3 4 1 1 1 1 1
ON4 4 4 5 1 1 1 1 1
ON4 5 5 6 1 1 1 1 1
IC1 0 IDCONC
IC2 1 0.0D0
IC3 1 1 1 0.0D0
IC4 1 1 1 1 0.0D0
IC5 1 0.0D0
IC6 1 1 100.0d0
IC7 1 1 1 0.0D0
XY1 1 90 0 0 0 0 time vs. chemical mass
0 0.00000000

```

## **APPENDIX D - TECPLOT SETUP INSTRUCTIONS**

APPENDIX D from *A Shipyard Program for NPDES Compliance*, NSRP Task N1-95-02, Applied Research Laboratory, State College, PA, July 2000

## INSTRUCTIONS TO RUN DISPERSION SIMULATION IN TECPLOT

When B.E.S.T. is run, it creates data sets that contain copper concentrations in the water column and in the sediment bed at all locations in the bay/estuary over time. These data sets, **bay\_c.tec** and **bay\_s.tec**, can be visualized in a time-lapse animation using TECPLOT software, available from Amtec Engineering, Inc. In order to get started in viewing the B.E.S.T. data in a pollutant dispersion animation, brief instructions have been provided below to set up basic parameters in TECPLOT to view the BEST data sets. Further details on using, modifying and defining attributes of the graphic display may be found in the TECPLOT User's Manual or On-line Help.

---

Open or run TECPLOT Version 7.0, 7.5 or 8.0 for MS Windows.

### **Load data file –**

Select Load Data File from the File Menu. When the Load Data Files dialog box pops up, be sure that the Load Data Files of Type box is set to see All Files (\*.\*). Browse until you find the data file you want to load, which should have a **.tec** file extension. This will be found in the MEDLEY folder under the folder name you selected to run the data set of interest. For example, select Medley\Tutorial\Bay\_c.tec. Load the file. A message will appear "Attempting to convert ASCII datafile to binary". Wait a few minutes while it performs this function.

You will get a graphic detail of San Diego Bay (or the body of water you have programmed into the software), with the mesh grid and a set of axes evident. It will cycle through a variety of colors until it reaches the end of its data set (<1 minute), or until you left click the mouse to stop it at any point.

Now you must set up the display panel to view the animation data properly.

### **Remove the axes –**

Select Edit from the Axis menu. In the Edit Axis dialog box, deselect the Show X-Axis check mark. Then select the Y-Axis button, and deselect the Y-Axis check mark. Now Close the Edit Axis dialog box. Select Redraw or Redraw All button and the Axes will disappear.

### **Turn off mesh –**

Select Mesh Attributes from the Field menu. The Mesh Attributes dialog box will appear. Select all lines of data in the white part of the box. This can be done by highlighting the first line of data, then, while simultaneously pressing the CTRL and SHIFT keys on the keyboard, page down through the data until the last data entry is reached. Then click on the last data entry. All data entries should be highlighted. Now click on the Mesh Show column title button and select No. The Mesh Show column for each data entry will change to “No” and several of the mesh attributes such as color will no longer show. Close the Mesh Attributes dialog box.

On the main screen in the upper left-hand corner, click to deselect (turn off) the Mesh check mark. Click to select (turn on) the Contour check mark.

### **Select contour variable –**

Select Contour Variable from the Field menu. Click on the scroll down arrow to see all selections and select either the C1 variable (concentration in the water column) or the CB1 variable (concentration in the interstitial sediment bed water). Close.

### **Select contour plot type –**

Select Contour Attributes from the Field menu. The Contour Attributes dialog box will appear. Select all lines of data in the white part of the box (they may still be highlighted). This can be done by highlighting the first line of data, then, while simultaneously pressing the CTRL and SHIFT keys on the keyboard, page down through the data until the last data entry is reached. Then click on the last data entry. All data entries should be highlighted. Now click on the Contour Plot Type column title button and select Flood. The Contour Plot Type column for each data entry will change to “Flood”. Close the Contour Attributes dialog box.

Click on the Redraw All button and wait a minute or so while the view is redrawn. A solid colored map of the bay will appear (no mesh) and you may or may not see various colored areas appear and disperse or disappear as the simulation is run.

### **Select contour levels –**

This is the most difficult step to describe, and will require some trial and error on the user’s part to find the best contour levels to display the range of data.

Determining the approximate concentration range - One way to get an idea of the range of concentrations for the data set is to select Spreadsheet from the Data menu. A spreadsheet of the data for the first

time interval will appear. By paging down through the data, looking at the concentrations for either C1 or CB1 (depending on which data set you are currently plotting), you may see the ranges of data for the data file you are currently viewing. Jot these ranges down. Select several different time intervals and review the data for each, jotting down the extremes (highest and lowest concentrations) of the data seen; for some time intervals all values may be zero. Close the Datasheet.

Reviewing the numbers you may see a range of, for example,  $1\text{e-}10$  to  $1\text{e-}06$ . These could then be used as starting points for setting up the range of contour levels to be displayed.

Viewing a rough order of magnitude simulation - Select Contour Levels from the Field menu. Click on the New Levels button. Enter the lowest concentration value seen (in the review above) in the Minimum Level box (format  $1\text{e-}10$ ), and the highest concentration seen (in the review above) in the Maximum Level box. Enter a number of levels; usually 8 or 10 is enough, and you may want to select a number that is easily divided by the number of orders of magnitude represented in your data set. For example, if you have 4 orders of magnitude, then 8 would be a good number of levels to select. Click on the Exponential Distribution radio button. Click the Okay button.

The new levels will be displayed in the Contour Levels dialog box and should be approximately evenly divided. Close the Contour Levels dialog box. Click on the Redraw All button to view the simulation.

Checking that all data is included, and fine tuning the simulation, Low concentration data – This is where the trial and error comes in. In order to make sure you are not missing low concentration data, select Contour Levels on the Field menu again. Change the levels to cover the range of the 2 or 3 orders of magnitude below the previously entered minimum value. For example, if  $1\text{e-}10$  was your minimum level before, then change the minimum and maximum ranges to  $1\text{e-}13$  to  $1\text{e-}10$ . Select Exponential Distribution radio button again. Close, Redraw All, and view the simulation again.

If all you see in the simulation is red (or whatever color you have selected for your highest concentration level), then all data in your data set is above the minimum level previously selected, and that is the proper setting for the minimum level. If however a lot of other colors (concentrations below the previously set minimum) are seen, then the minimum should be set lower. Reset the Contour Levels to reflect this fact and try again. Continue this process until the proper minimum level is identified.

High concentration data - Repeat the sequence above to make sure you are not missing any high concentration data. Change the levels to cover the range of the 2 or 3 orders of magnitude above the previously entered maximum value. For example, if 1e-6 was your minimum level before, then change the minimum and maximum ranges to 1e-3 to 1e-6. Select Exponential Distribution radio button again. Close, Redraw All, and view the simulation again.

If all you see in the simulation is blue (or whatever color you have selected for your lowest concentration level), then all data in your data set is below the maximum level previously selected, and that is the proper setting for the maximum level. If however a lot of other colors (concentrations above the previously set maximum) are seen, then the maximum should be set higher. Reset the Contour Levels to reflect this fact and try again. Continue this process until the proper maximum level is identified.

Setting the proper concentration range - Now select Contour Levels from the Field menu one more time. Enter your proper minimum and maximum levels, readjust the number of levels as desired, select the Exponential Distribution radio button, Close, Redraw All and view the simulation again. This simulation now scans the entire range of data in your data set and gives an accurate representation of the data generated by the BEST model.

#### **Select contour legend –**

Select Contour Legend from the Field menu. Click on the Show Contour Legend check mark box. Other legend attributes may be selected or modified to the user's preference. Close the Contour Legend dialog box. Click on the Redraw All button and wait a minute or so while the view is redrawn. The Legend will appear.

#### **Label contour legend –**

Click on the Ab button under Tools on the left side of the screen to select the text drawing tool. Move the tool to the area above the legend. Left click the mouse at the starting point for the text. When the mouse button is released the Text dialog box will appear. Type in the legend heading as desired (units are kg/cubic meter). Modify other text attributes as desired and Close the Text dialog box. The Legend label will appear.

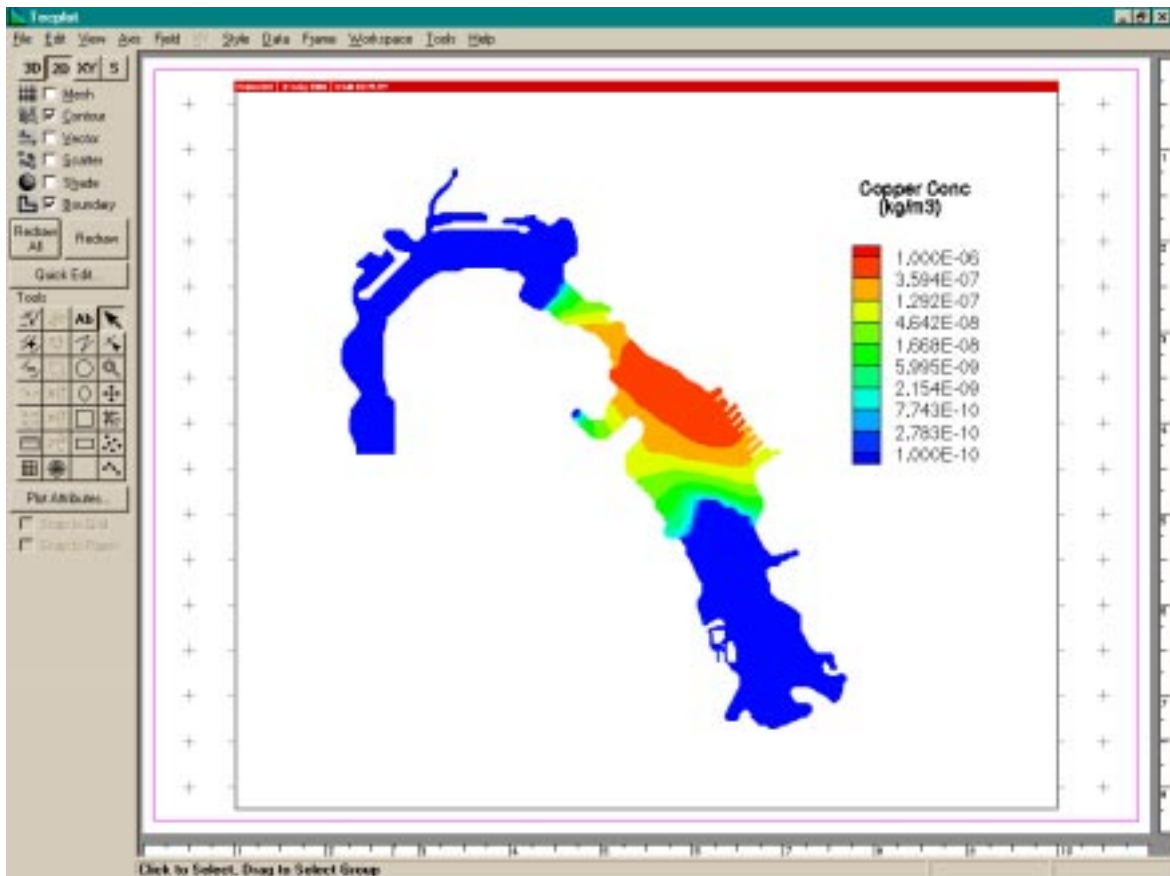
The text can be moved to another location by clicking on the text and then dragging it to a new location. Double clicking on the text will bring up the Text dialog box to edit the text other its attributes.

Additional text labels can be added according to user's preference, for example to label ocean boundary, or important locations such as shipyards, harbors, city docks, etc.



Click on the Redraw All button to restart the animation with all the modified parameters in place. Clicking the mouse at any time while the animation is running will stop the animation at that point.

A sample final screen of a B.E.S.T./TECPLOT animation in San Diego Bay is illustrated below.



Saving the file and the layout.

### **Save layout –**

The layout can be saved to use when opening future data files. To save the layout, select Save Layout As from the File menu. Name and save as usual.

When opening a new data file, Select Open Layout from the File menu and select the saved layout. Then select Load Data Files from the File

menu and open the desired data file. Note that the Contour Levels will need to be edited for a new data set in order to see all the data in an appropriate manner.

**Save data set with layout –**

To save the data set with the layout, select Write Data File from the File menu. Click Okay on the Data File Options dialog box. The Write Data File dialog box will appear. Name and save as a file with the .plt file extension. The layout, labels, legend, contour levels, etc will be save with the data set for quick and easy viewing at a later date.

## **APPENDIX E – GMS FEMWATER INSTRUCTIONS**

APPENDIX E from *A Shipyard Program for NPDES Compliance*, NSRP Task N1-95-02, Applied Research Laboratory, State College, PA, July 2000

## **GMS FEMWATER INSTRUCTIONS**

GMS FEMWATER is a 3D finite element, saturated/unsaturated, density driven, flow and transport model which includes a graphical interface. It was written by Dr. G. T. Yeh and the U.S Army Engineer Waterways Experiment Station. For the NPDES modeling programs presented here, the GMS FEMWATER software is needed for two purposes – identifying the nodes to run the models for new locations within/on San Diego Bay, and for installing the information necessary to adapt these models to different bodies of water.

### **Obtaining GMS FEMWATER**

The GMS FEMWATER numerical modeling program is available for free to DoD, EPA, and DoE personnel and to DoD, EPA, and DoE contractors. Information on obtaining the program is available at the following Web Site:

<http://chl.wes.army.mil/software/gms/gmsdl.htm>

The program can be downloaded directly from the Web site, and a demo version is available to anyone. Also available at the site are forms that can be used to register your DoD, EPA, DoE affiliation which then allows full use of all software options. Copies of these registration forms are included at the end of this Appendix.

Persons or organizations that are not affiliated with any of the above government departments can purchase GMS FEMWATER. Contact information for purchase is also available at the Web site listed above.

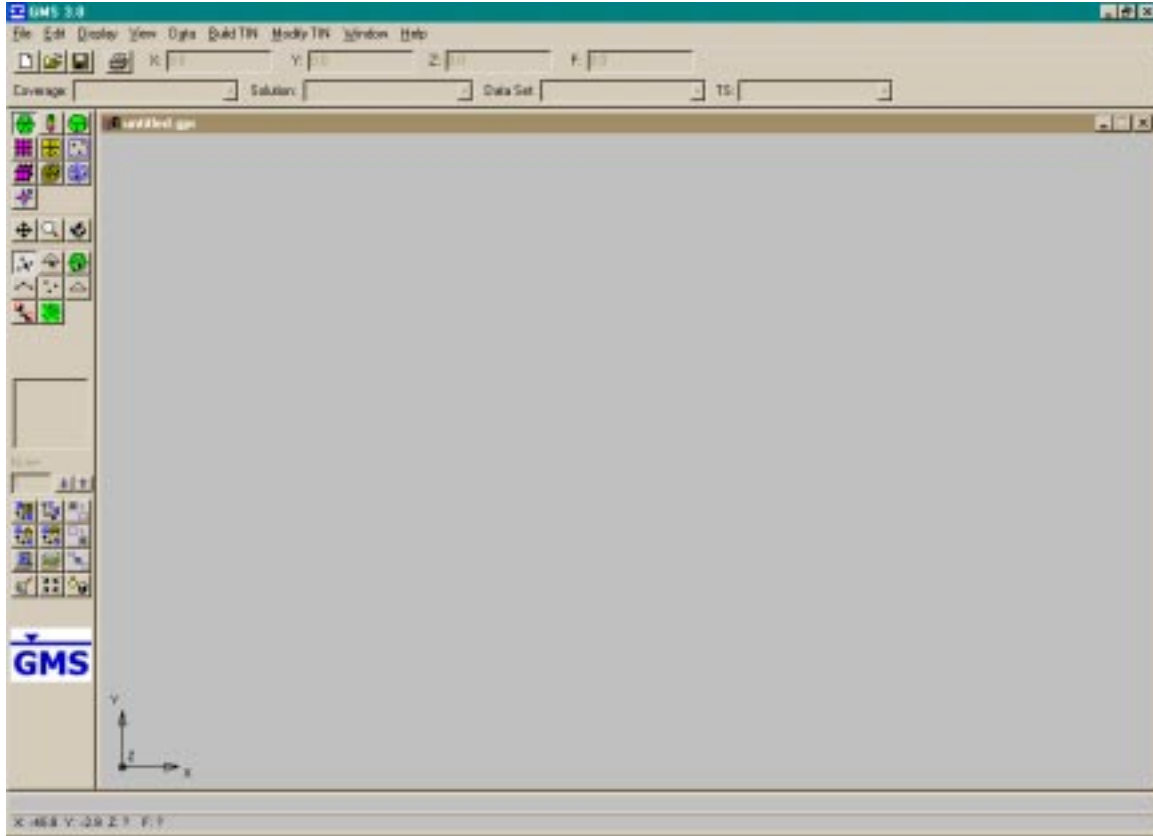
### **Identifying Nodes and x,y locations within San Diego Bay**

Install GMS FEMWATER on your computer.

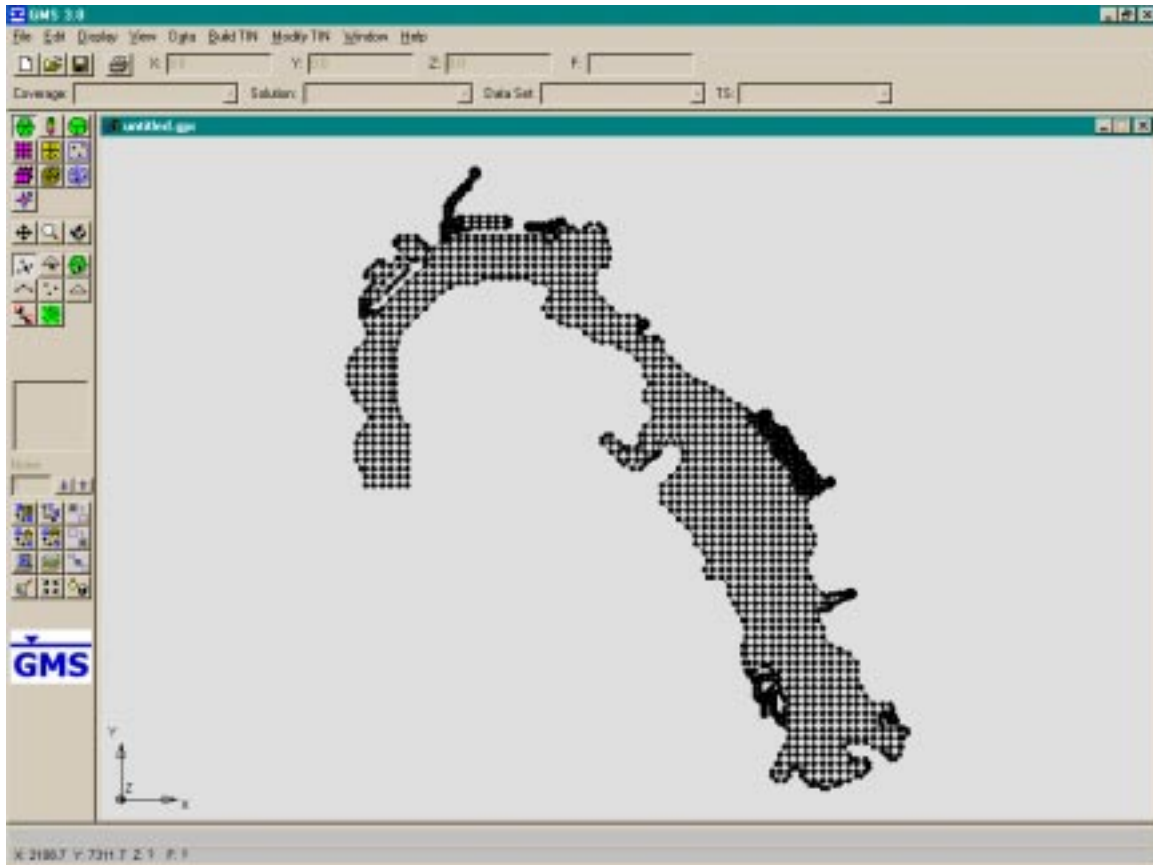
Using Program Manager or My Computer, navigate to the file location where you installed GMS FEMWATER.

Click on the GMS30 Application file name to begin execution of the software.

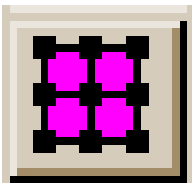
The following screen will appear:



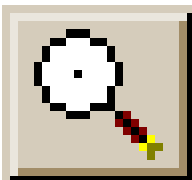
Select **Open** from the **File** menu, and navigate to the **MEDLEY** folder. Double click on the file named **Bay\_gms** to open it. The San Diego bay grid will now appear on your screen, and your screen will look like the following:



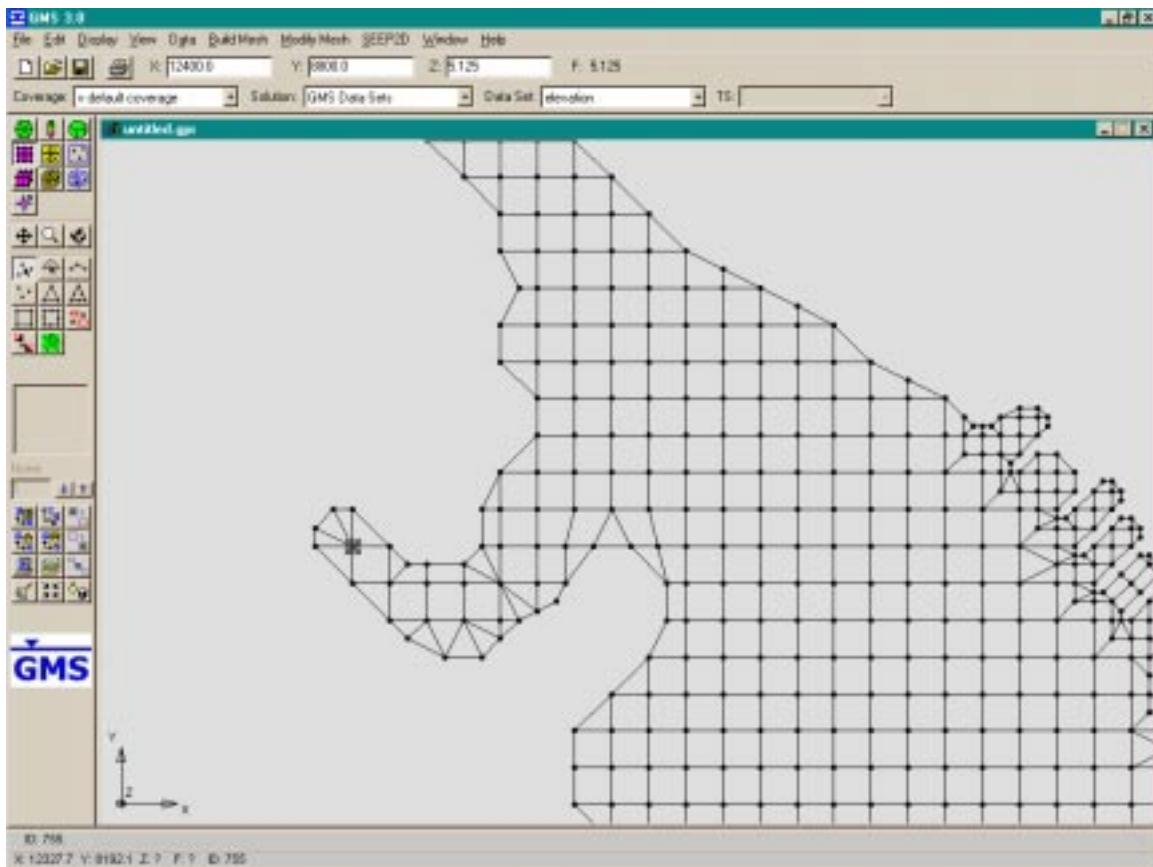
In the upper left hand corner of the screen, select and click on the **2D Mesh Module** button, which looks like this:



If desired, select the **Magnifier** button in order to zoom in closer to the desired region of San Diego Bay. The magnifier button looks like this:



Click and drag a rectangle to zoom in on the desired area. Your screen will now look like:



Now click on a node of interest. The lower left hand corner of the screen will display an ID number (755 in the example below) and a set of x and y location coordinates (12327.7 and 8192.1 in the example below).

San Diego Bay

The x,y coordinate information can be used to define a specific region of interest when doing the EcoRisk model. The node ID can be used to identify specific nodes in San Diego Bay where a facility might be located. These would be used for entering data into the B.E.S.T. model for a facility other than NASSCO on San Diego Bay.

# GMS REQUEST FORM

---

This form is intended for use by US government personnel for the express purpose of requesting copies of software (portions of which are proprietary) developed through a joint effort of a consortium of US government and university participants. The federal consortium agencies are:

US DEPARTMENT OF DEFENSE  
US ENVIRONMENTAL PROTECTION AGENCY  
US DEPARTMENT OF ENERGY

**Only members of the federal consortium may use this form to request the software.** On-site contractors to these federal agencies are permitted to use the software only for projects directly funded by a consortium member. The term "on-site contractor" means that the contractor must be physically located at a site owned by a consortium member and engaged solely in US government business. Requests for software by contractors must be made by a representative from the federal consortium.

---

## INSTRUCTIONS

<u>To Request GMS For DoD/EPA/DoE Use:</u>	<u>To Request GMS For DoD/EPA/DoE On-Site Contractor Use:</u>
1. Fill out Section 1 of request form	1. Fill out Sections 1 & 2 (must be filled out by DoD/EPA/DoE requestor)
2. Fax/mail form to address below	2. Fax/mail form to address below
3. Download GMS from Web Site	3. Download GMS from Web Site
4. Send in Security String to obtain password	4. Send in Security String to obtain password

---

### To Visit Our GMS WEB Site And/Or Obtain GMS:

<http://chl.wes.army.mil/software/gms>

### Fax Or Mail Completed GMS Request Form To:

USAE Waterways Experiment Station  
Coastal and Hydraulics Laboratory  
ATTN: CEWES-CE-MG  
3909 Halls Ferry Road  
Vicksburg, MS 39180-6199  
(601) 634-4286 (voice)  
(601) 634-4208 (fax)

---



I formally request a copy of the Department of Defense **Groundwater Modeling System (GMS)** for the purpose of conducting groundwater analyses for consortium members of the United States Government. The following information is provided for **GMS** authorization.

Section 1: To be completed by DoD/EPA/DoE Personnel when requesting GMS password.

Sections 1&2: To be completed by DoD/EPA/DoE Personnel when requesting GMS password for on-site contractor.

---

Section 1: Government Requestor Information

Please check one: <input type="checkbox"/> DoD <input type="checkbox"/> EPA <input type="checkbox"/> DoE	
Name:	Title:
Organization:	
Complete Mailing Address:	
Phone Number:	Fax Number:
E-Mail Address:	
Computer Configuration (cpu type, RAM, OS):	
Project Site/Installation Name:	

---

Section 2: On-Site Contractor Information

Name:	Title:
Contractor's Organization:	
Complete Mailing Address:	
Phone Number:	Fax Number:
E-Mail Address:	
Computer Configuration (cpu type, RAM, OS):	
Contract Length for <b>GMS</b> Use:	
Project Site/Installation Name:	
Specific Use of GMS in Project:	

I understand that the copy of **GMS** requested will only be used by either US Government personnel who are employees of one of the federal consortium members or by a consortium member's on-site contractor located at a government owned site. I also understand that **GMS** may not be used on any non-consortium funded projects by on-site contractors and that it is the *exclusive* responsibility of the Waterways Experiment Station to distribute gratis copies of **GMS**. No copies of the program will be distributed outside my immediate organization by me or anyone in my organization.

US Gov't Requestor's Signature: \_\_\_\_\_ Date: \_\_\_\_\_

GMS Security String (if known): \_\_\_\_\_

For more information about the  
National Shipbuilding Research Program  
please visit:

**<http://www.nsrp.org/>**

or

**<http://www.USAShipbuilding.com/>**